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Characterization and Biomechanical Analysis of the Human Lumbar Spine with *In Vitro* Testing Conditions

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of the Human Lumbar Spine with

In Vitro Testing Conditions

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A thesis submitted to the faculty of
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Master of Science

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ABSTRACT

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Biomechanical testing of cadaveric spinal segments forms the basis for our current understanding of healthy, pathological, and surgically treated spinal function. Over the past 40 years there has been a substantial amount of data published based on a spinal biomechanical testing regimen known as the flexibility method. This data has provided valuable clinical insights that have shaped our understanding of low back pain and its treatments.

Virtually all previous lumbar spinal flexibility testing has been performed at room temperature, under very low motion rates, without the presence of a compressive follower-load to simulate upper body weight and the action of the musculature. These limitations of previous work hamper the applicability of published spinal biomechanics data, especially as researchers investigate novel ways of treating low back pain that are intended to restore the spine to a healthy biomechanical state. Thus, the purpose of this thesis work was to accurately characterize the rate-dependent flexibility of the lumbar spine at body temperature while in the presence of a compressive follower-load.

A custom spine simulator with an integrated environmental chamber was developed and built as part of this thesis work. Cadaveric spinal motion segments were tested at 12 different rates of loading spanning the range of voluntary motion rates. The testing methodology allowed for comparison of spinal flexibility at room and body temperatures in the three primary modes of spinal motion, both with and without a compressive follower-load. Additionally, the work developed a stochastic model for rate-dependent spinal flexibility that allows for accurate prediction of spinal flexibility at any rate within the range of voluntary motion, based on a single flexibility test.

In conclusion, the biomechanical response was significantly altered due to testing temperature, loading-rate, and application of a compressive follower-load. The author emphasizes the necessity to simulate the physiological environment during *ex vivo* biomechanical analysis of the lumbar spine in order to obtain a physiological response. Simplified testing procedures may be implemented only after the particular effect is known.

Keywords: spine, biomechanics, viscoelasticity, loading-rate, temperature, follower-load, range of motion, neutral zone, stiffness, hysteresis, DIP-Boltzmann

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NOMENCLATURE

AF	Annulus Fibrosus
AR	Axial Rotation
FE	Flexion Extension
FSU	Functional Spinal Unit
H	Hysteresis
IVD	Intervertebral disc
K	Neutral-Zone Stiffness
LB	Lateral Bending
LBP	Lower Back Pain
LK	Lower Neutral Zone Stiffness
NP	Nucleus Pulposus
NZ	Neutral Zone
ROM	Range of Motion
QOM	Quality of Motion
UK	Upper Neutral Zone Stiffness

1. INTRODUCTION

1.1. Motivation

Lower back pain has been deemed an epidemic that is plaguing the modern world. It ranks in the top 5 causes for surgical procedures, hospital admissions, physician visits, and activity limitations for individuals younger than 45 years of age [1-5]. With such a large and expanding pool of patients, people are desperate to reduce the chronic, debilitating pain in their lower back [6] and often seek relief through suboptimal procedures.

Spine biomechanics is a rapidly advancing discipline that is regularly producing innovative models [2, 7-12] and medical devices [13-19] with the hope of providing relief. Spinal biomechanical studies enhance our understanding of the healthy, injured, and aging spine [20, 21]. These studies also provide target behavior for medical devices and validation criteria for analytical spine studies [13, 14, 16, 17, 21-25]. Biomechanical testing of cadaveric spinal segments forms the basis for our current understanding of healthy, pathological, and surgically treated spinal function; however, the *ex vivo* experiments on cadaveric test specimen introduce multiple sources of error. Without a complete knowledge of the *in vivo* workings of the spine, the *ex vivo* experimental conditions should most nearly mimic those conditions experienced in the body. “In order to understand the mechanics of the spine, the material properties of the involved structures must be understood" [26], and this is only accomplished while replicating the physiological conditions.

Virtually all previous lumbar spinal flexibility testing has been performed at room temperature, under very low motion rates, without the presence of a compressive follower-load to simulate upper body weight and the action of the musculature. These limitations of previous work hamper the applicability of published spinal biomechanics data, especially as researchers investigate novel ways of treating low back pain that are intended to restore the spine to a healthy biomechanical state.

Temperature, loading-rate, and a compressive pre-load are known to affect the biomechanics of the functional spinal unit (FSU) [26-32], however the magnitude of these effects has not been comprehensively reported in literature for biomechanical testing of spine segments. The bulk of reported spine biomechanics tests were performed at room temperature rather than body temperature [17, 20, 29, 32-40], which may cause the mechanical behavior to be significantly altered from the *in vivo* state. Various rates of loading have been used in biomechanics studies [13, 14, 17, 22, 25, 40, 41]; however a systematic investigation of the effects of altered loading-rates is currently lacking, and a method for comparing test results obtained at different loading-rates does not exist. Additionally, most of the existing studies that have addressed either temperature or rate dependence were conducted before the adoption of a compressive follower-load as a standard for testing, which may reduce or magnify their individual effects.

While many aspects of current testing are controlled to simulate *in vivo* conditions, it is common practice to test biological tissue (including spines) at non-physiological temperatures; furthermore, a standard rate of loading has not been established. Such practices will significantly alter the observed response, which translates to incorrect design parameters and/or boundary conditions for the respective medical devices and models.

1.2. Objective

The objective of the proposed research was to build on past work by characterizing the biomechanical effects of a compressive follower-load, testing temperature, and loading-rate, with respect to the torque-rotation response of the human lumbar spine. This is accomplished by comparing current experimental methods with its physiological counterpart, and thereby learning how the specific testing conditions alter the torque-rotation response. All three primary modes of loading were investigated using both stepwise and dynamic loading protocols. Flexion-extension flexibility was examined in substantially more detail by investigating 11 distinct loading-rates with a redundant testing protocol. Based on this data, we developed a stochastic model that accurately predicts the segmental flexibility of a lumbar spine segment at any rate within the physiologic range based on a single flexibility test.

This study was approached with the hypothesis that the effects of the test conditions would adhere to basic material mechanics and viscoelastic theory. Specifically, testing with increased loading-rates, reduced temperatures, and the application of a compressive follower-load, would each increase the stiffness of the spine segment in all primary modal loading directions. Viscoelasticity was hypothesized to affect the torque-rotation response in all loading-directions (axial-rotation, flexion-extension, and lateral-bending), such that increased loading-rate would decrease segmental range of motion, and increased temperature would decrease segmental range of motion. These two aspects produce opposite effects, which may counteract the other; however, this has not been investigated before.

1.3. Document Organization

The remainder of this thesis is organized to guide the reader through the research performed. Chapter 2 contains background information about the spine and different methods of testing the biomechanics. Chapter 3 introduces the spine testing apparatus that was developed to analyze the various testing conditions. Chapter 4 outlines the methods used to test the sensitivity of the spine biomechanical response to testing temperature, a compressive follower-load, and various loading-rates. Chapter 5 presents the results of the tests that analyzed the testing temperature and compressive follower-load effects. Chapter 6 reveals the effects of testing at various loading-rates, as well as introducing a stochastic model for predicting the torque-rotation response of a spinal segment at different continuous-speed loading-rates. Chapter 7 contains a summary of the work performed and recommendations for future work.

2. BACKGROUND

2.1. Vertebral Column

The vertebral column is commonly referred to as the spine and consists of 33 individually unique vertebrae, beginning superiorly at the inferior region of the skull and descending inferiorly to the pelvic region. In general, each adjacently inferior vertebra is morphologically larger than the one superior due to the increased loading experienced at that particular vertebral level.

The vertebral column of a healthy adult spine naturally has a double-S curve shape in the sagittal plane; this curvature is segmented as lordosis and kyphosis (Figure 2.1). Any curvature that is naturally present in any other viewing plane (e.g, transverse, coronal) is indicative of a pathological condition, such as scoliosis. The natural, or primary, curvature of the infantile spine is purely kyphotic while the lordotic curves are formed secondary to weight bearing in the vertebral column. This interesting combination of lordosis and kyphosis results in a non-intuitively stable structure [42].

The vertebral column is divided into 5 regions: cervical, thoracic, lumbar, sacral, and coccygeal (Figure 2.1). Any particular vertebra is referred to according to the region and its numerical position, numbered superior to inferior. For example, the third vertebra from the top of the lumbar region is referred to as the L3 vertebra, and the ninth vertebra from the top of the thoracic region is referred to as the T9 vertebra. The cervical region makes up the seven superior vertebrae (C1-C7), including the atlas (C1) and the axis (C2). The thoracic region consists of the next twelve vertebrae (T1-T12), which provide a stable attachment for the connected ribs. The lumbar region consists of 5 vertebrae (L1-L5), and is the primary area of interest for researching lower back pain. In adults, all five sacral vertebrae are all fused together to form one solid structure referred to as the sacrum. The coccygeal region (i.e., the tailbone) consists of four to five small vertebrae, which are also fused.

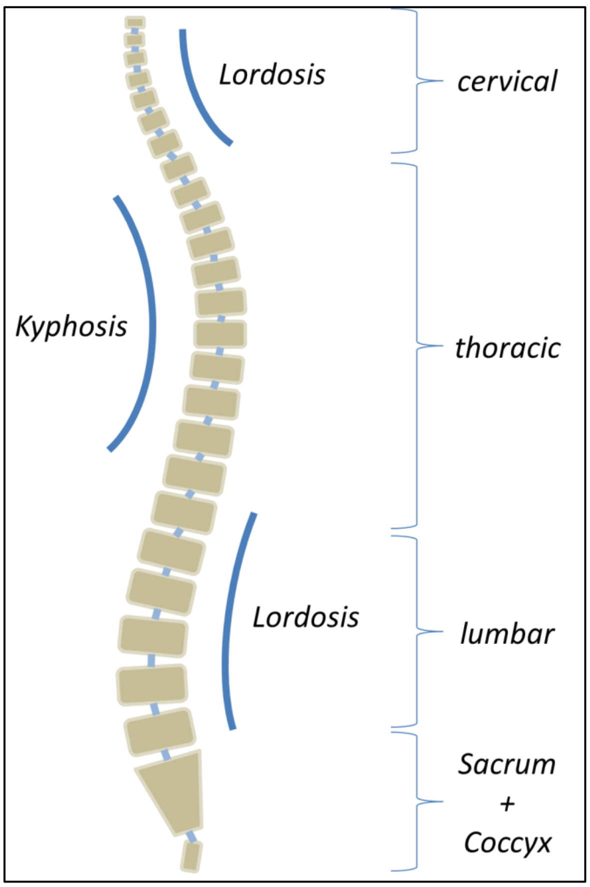

Figure 2.1: Sagittal simulation of the human vertebral column

The functional spinal unit (FSU) is defined as the smallest segment of the spine that captures the kinetic and kinematic motion [43] of the vertebral column. It is composed of all the passive elements that connect two adjacent vertebrae; specifically, it contains a superior and inferior vertebra, up to 7 spinal ligaments (e.g., anterior longitudinal, posterior longitudinal, flavum, interspinous, supraspinaous, and intertransverse ligaments; and the facet capsules), and a thick cartilaginous pad called the intervertebral disc. The integration of these elements creates a joint that allows a limited range of motion, while simultaneously protecting the neural structures within. While several small stabilizing muscles also surround the vertebral column and connect each adjacent vertebra, they actively control the motion of the spine, and are therefore not considered part of the FSU.

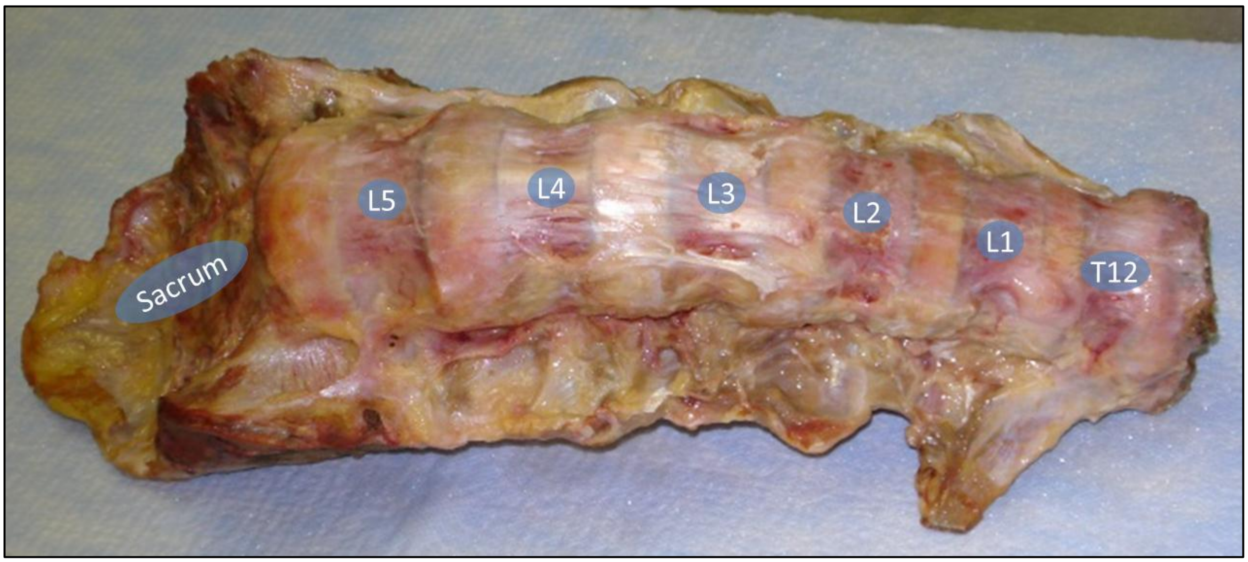

Figure 2.2: A fresh-frozen, human lumbosacral spine specimen

2.2. Intervertebral Disc

The intervertebral disc (IVD) is a fibrocartilaginous pad that separates each adjacent vertebra between C2 and S1, thus offering a moveable connection within the kinetic chain of the vertebral column [8]. They create an amphiarthrotic synchondrosis joint between a superior vertebra and its adjacent inferior vertebra, resulting in a total of 23 IVDs in the spine.

IVD size varies greatly among individuals, depending on their size (i.e., height and weight) and lifestyle. The size also varies within an individual based on the location (e.g. region and superior/inferior), which is largely correlated with function. The cervical IVDs are smaller diametrically, which allow a greater segmental range of motion, when compared to the lumbar vertebrae. The thoracic region is "relatively inflexible" [26]. As the lumbar spine is the most inferior spinal region with IVDs, it also carries the largest load. All the vertebrae and the separating IVDs form the uninterrupted and incrementally moveable structure called the vertebral column.

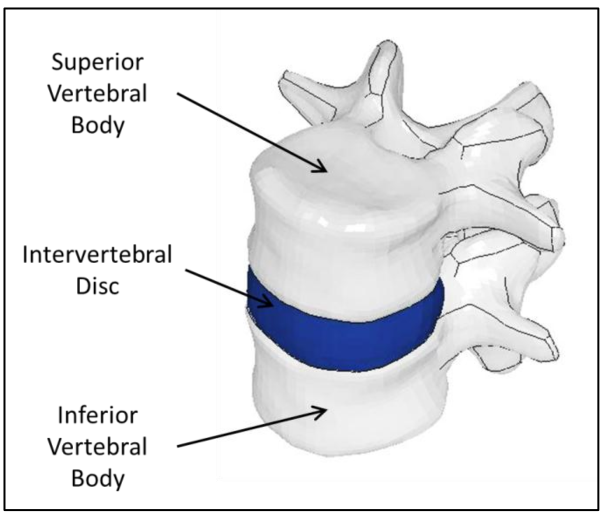

Figure 2.3: The functional spinal unit (excluding spinal ligaments)

The characteristics of an IVD are similar to other cartilage that is found in the body, such that it exudes nonlinear and viscoelastic properties, which is characteristic of the anisotropic microstructure and composite structure. While each is different in size, shape, and biomechanical motion, each IVD follows the same general morphology: a nucleus pulposus is encapsulated about the perimeter by the annulus fibrosus and superior-inferiorly by the vertebral endplates [44], which is composed of multiple thin layers of hyaline cartilage that line the superior and inferior surfaces of the vertebral bodies and regulate nutrient diffusion [10].

The nucleus pulposus is a gelatinous, hydrogel-like composite (approximately 20% dry weight) of arbitrarily oriented (20% type-I, 50% type-II) collagen fibers that are embedded in a proteoglycan matrix [3]. Within the nucleus pulposus reside the notochordal cells that are surrounded by a proteoglycan matrix of chondrocyte cells. The proteoglycans (mainly aggrecan) bind to long chains of hyaluronic acid to form a viscous substance that absorbs water, and enables the nucleus pulposus to withstand compressive loads. Due to the sealed environment that the nucleus pulposus resides in, it acts as a mechanical damper [9, 45]. The hydrostatic pressure that is caused by the vertical loading of the vertebral column translates to tensile stresses in the fibers of the annulus fibrosus.

The annulus fibrosus is composed of 7-15 concentric lamellar bands of fibrocartilage with highly organized, and cross-linked (50% type-I, 30% type-II) collagen fibers that are oriented at alternating oblique angles with each band. The annulus fibrosus bands are very effective at resisting the tensile forces produced from the NP pushing outwards during loading of the spinal column [9, 44-46].

2.3. Spine Biomechanics

The application of the engineering principles of mechanics and dynamics to biological structures has resulted in the specific field of biomechanics, “a modern subject with ancient roots” [47]. Spine biomechanics studies the motion and components of the spine to understand more about its mechanical behavior: why does it move the way it does, what is the function of the spinal ligaments, or how could a mechanical system mimic this same behavior? Studies can be done to understand the ideal behavior of a healthy spine and also the pathological behavior of the unhealthy spine.

The biomechanical results that have been obtained thus far for load sharing are limited to a quasi-static single modal (flexion-extension, lateral-bending, or axial-rotation) loading. Based upon the literature available, there are few tests performed that involve complex dynamic loading. There are even fewer studies that compare the two methods with application to orthopaedic devices.

Generally, engineers think of unstable structures as exhibiting a high positional sensitivity to mechanical loads. However, this terminology has become confused in the spinal biomechanics literature, due to the conflicting definition of instability by clinicians. Clinicians define a joint (such as a spinal motion segment) as being unstable when self-induced motion of the joint causes pain. For the purposes of this thesis, we will utilize the traditional engineering definition, as applied to spinal biomechanics, and as restated by Sengupta such that, "'instability' implies an abnormal motion under physiologic load. The [end] effect of disc degeneration is to reduce the movement, not to increase it" [48]. The reduced movement (secondary to disc degeneration) is caused by increased stiffness, which is seen in the advanced stages of disc degeneration. In the early stages of disc degeneration the IVD appears less stiff; however, as the degeneration advances, the nucleus pulposus loses more of the proteoglycan matrix, along with its ability to hold water, and the disc height decreases. This results in increased mechanical stiffness.

Efforts are being made to obtain a more physiological testing environment. Moisture-content is preserved as spine testing has simulated the wet, *in vivo* environment within a 100% relative humidity (RH) testing chamber [35], or the bulk of recent literature has specified intermittent saline spritzing of the soft tissue to prevent specimen dehydration [17, 20, 29, 31-40, 49-54]. Where stepwise loading previously encouraged motion by manually applying static weights [18, 30, 55], a continuous-speed loading protocol is now the norm [30, 56-58] as technological improvements have been implemented by introducing electric motors, control mechanisms and system feedback.

The characteristics of the intervertebral disc are similar to other biological materials in the body, such that it exhibits anisotropic, viscoelastic behavior [28, 59]. Researchers have reported segmental spine flexibility results with and without a compressive follower-load while performing biomechanical analysis at room temperature. Specimen temperature is also expected to change the biomechanical response of a lumbar FSU because of its viscoelastic behavior. Implications of viscoelasticity include rate-dependence, stress relaxation (and/or creep) [42], and hysteresis [10, 33, 58, 60].

2.3.1. Flexibility Testing

Two methods have been proposed for spine biomechanics testing: the flexibility method and the stiffness method [51]. The flexibility method involves applying a load (i.e., force or moment) to the free end of the spine, with the opposite end fixed, and measuring the displacement (i.e., translation and rotation) due to the load. The stiffness method is similar; it involves applying a displacement to the free end of the spine, and measuring the resulting load.

While the two methods may seem to be the reciprocal of the other, the flexibility method has become the standard for spine biomechanics tests [37, 51] as it allows natural motion. Every motion may be achieved using the stiffness method as the displacement is the input; however, the body is not capable of achieving every possible motion that the stiffness method may apply. Rather, voluntary motion in the body is achieved through the active contraction of muscles, which induces a moment, and therefore produces a rotation. This scenario (i.e., voluntary, physiological motion) embodies the target conditions of spine biomechanics testing.

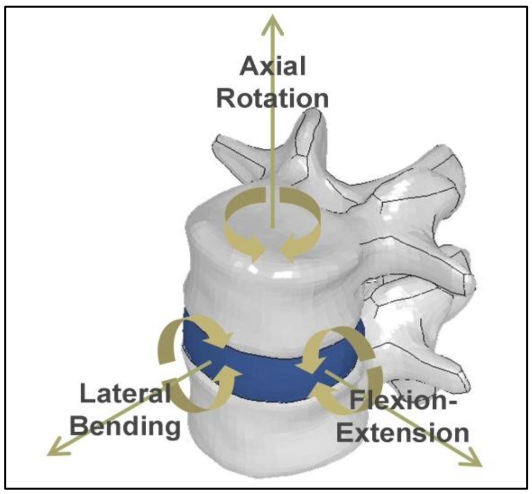

Figure 2.4: Three modal loading directions of the functional spinal unit

The Bernoulli-Euler theory states that the curvature at a particular point on a beam is directly proportional to the moment acting at that point [61], such that

$$\frac{d\theta}{ds} = \frac{E \cdot I}{M}, \qquad (2\text{-}1)$$

where E is the modulus of elasticity of the material, I is the area moment-of-inertia of the cross-section, M is the applied moment, and $d\theta/ds$ is the curvature of the beam. While this equation remains valid, the vertebral column does not have a constant modulus of elasticity nor constant cross sectional properties (i.e. the area moment-of-inertia). Therefore the curvature is not constant with a constant moment applied, and physical testing is required to understand the segmental motion patterns. This contributes to the validity of performing flexibility testing of a single-level functional spinal unit.

2.3.2. Pure Moment Load

The vast majority of the curvature in the vertebral column results from the rotation within the intervertebral disc, and insignificant bending occurs within the vertebrae as the bone is rigid compared to the intervertebral disc. The moment that causes this curvature can only be consistently determined if a pure moment load is used. A pure moment load is applied so that the driving force for bending the spinal segment is constant throughout the entire length of the spine, as shown in **Figure 2.5**, and no shear force is transferred through the segment. This would not be true with an applied force.

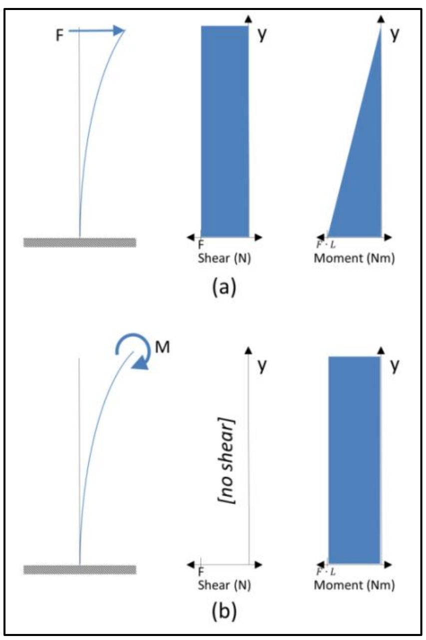

Figure 2.5: The shear and bending moment diagrams for a vertical fixed-free beam loaded with (a) a force in the horizontal-direction and (b) a pure bending-moment

2.3.3. Loading Protocol

Traditionally, spine researchers tested flexibility using a quasi-static, stepwise loading protocol, which involves applying the load in select increments of torque to the predetermined limit and holding each step for a specified time, therefore obtaining a pseudo-static response of the segment at the respective positions. The majority of researchers have recently begun moving away from stepwise loading in favor of performing flexibility tests on the spine using a continuous-speed, dynamic loading protocol with loading-rates that are *ad hoc* toward "very slow" [40, 57, 58].

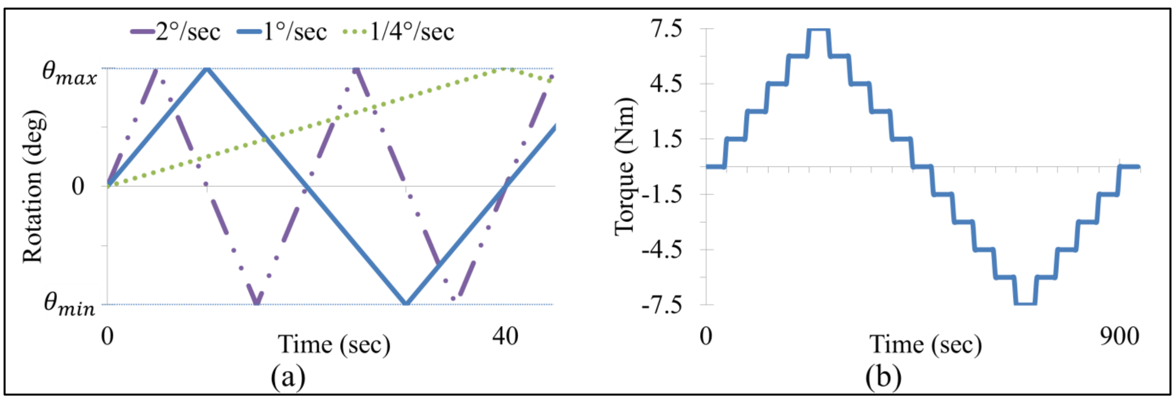

Figure 2.6: Graphical representation of (a) dynamic loading and (b) stepwise loading

2.3.4. Compressive Follower-load

Efforts have been made recently in spine biomechanics research to better simulate the *in vivo* environment by including a compressive follower-load during spine flexibility tests. This load simulates the mechanical loads supported by the spine during normal activities. Approximate forces supported in the spine due to various activities are presented in Table 2.1.

An applied compressive follower-load simulates a physiological environment by forcing the intervertebral disc to support the portion of the body weight transmitted through the spine.

This load pressurizes the nucleus pulposus and imposes a pre-strain in the fibers of the annulus fibrosus, as represented in Figure 2.7. These effects may alter the biomechanical response of the FSU by changing the stiffness of the intervertebral disc.

Table 2.1: Approximate force experienced on the L3-L4 disc of the average male [62]

Activity	*Force (N)*
Awake	250
Upright sitting (no support)	700
110° sitting with back rest	400
Standing	500
Flexed 20°, Rotated 20°, 10 kg weight	2100
Holding 5 kg arms extended	1900
Lifting 10 kg, back bent	1900

A compressive follower-load is commonly applied to simulate the load-bearing of a component of the body weight that is supported by the spine and the individual FSU [39, 63-68]. A compressive load is expected to alter the FSU biomechanical response due to the following mechanics:

- The disc height decreases [2, 69], which causes spinal ligaments to relax as the FSU is compressed and partial load transfer through the posterior facet joints increase.
- The instantaneous axis of rotation (IAR) shifts as the load is transferred to the facets [14, 19, 22].
- The IVD stiffens as the nucleus pulposus is pressurized [25, 62]

The stiffening of the FSU is contradictory to beam theory, which states that a compressive axial load decreases the stiffness of a beam [61]; however, the mechanics are explained when the intervertebral disc is treated as a pressure vessel. Upon compression, the nucleus pulposus is pressurized [70] (Figure 2.7) and pushes outward on the annular fibers of the IVD. This causes the disc to expand and the annular fibers become taught, effectively stiffening the FSU.

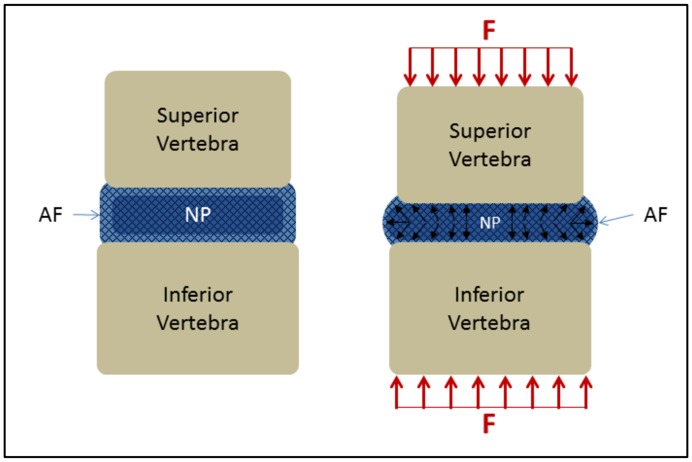

Figure 2.7: A compressive follower-load increases the pressure inside the intervertebral disc

2.3.5. Viscoelasticity

Biological soft tissue often exhibit characteristic mechanics of viscoelasticity as they integrate the mechanical response of a fluid and a solid, elastic material. Specifically, the mechanical response of viscoelastic material is contingent on the water content and temperature of the specimen, as well as the rate of mechanical strain [28, 47, 59, 71-74]. Testing of viscoelastic materials has shown a correlation of the mechanical response with temperature, moisture-content, and bending-rate [2, 27-29, 56, 75, 76]. It is this property of biological tissue that requires simulating the testing environment to match those of the human body, such that tendons may be more flexible at low strain rates or high temperatures and less flexible at high strain rates or low temperatures [27, 74].

Recent work has shown a decreased range of motion and neutral zone on the porcine cervical spine with dynamic loading, when compared to stepwise loading [30]; however, this has not been observed in the human specimen, and no studies have been found comparing different continuous-speed loading-rates. While dynamic loading is congruent with *in vivo* kinesiology, there is inconsistency in the choice of loading-rate across spinal flexibility studies. Because of this lack of rate-dependent spinal flexibility data, our current understanding of spinal flexibility has primarily been derived from very low rate and quasi-static data.

2.3.6. Flexibility Parameters

When performing spine biomechanics testing, it is often a daunting task to express every point recorded in the dataset for the spine. For this reason, flexibility parameters are often used to describe the torque-rotation response in a simple, concise manner. Common parameters used to evaluate and compare biomechanical flexibility data from spinal studies include the segmental range of motion, and the quality of motion is captured through the neutral-zone stiffness and various metrics for defining the "neutral zone" where small changes in loading result in large changes in segmental motion [13, 14, 17, 18, 21, 33, 34, 56, 77-79]. Another parameter used in this research included a measure of the hysteresis of the torque-rotation response as it captures the irreversible torque-rotation behavior [13-15, 17-19, 21, 22], since the motion does not track the same path for the loading and unloading curves. More information is given in Section 4.5.1, Table 4.4, and Figure 4.4.

3. MULTI-AXIAL SPINE SIMMULATOR UNDER A CONTROLLED ENVIRONMENT (MASSUCE)

In order to investigate the sensitivity of the spine biomechanical response to various testing conditions, the first task of this thesis work was to develop a custom spine tester to simulate the motion of various spine segments while altering any number of testing conditions in all three modal directions of loading: axial-rotation, flexion-extension, and lateral-bending. The design was based on a study published by Oxland et al. [30], which uses a spline shaft and two universal joints to transfer the load from a motor to the test specimen (**Figure 3.1**), which results in a pure moment load. The method of securing the test specimen using upper and lower potting fixtures, as shown in **Figure 3.2**, is also similar to previously reported simulators [26, 58]. The tester was substantially modified by including a compressive follower-load, a multi-camera three-dimensional motion tracking system, and an environmentally controlled testing-chamber.

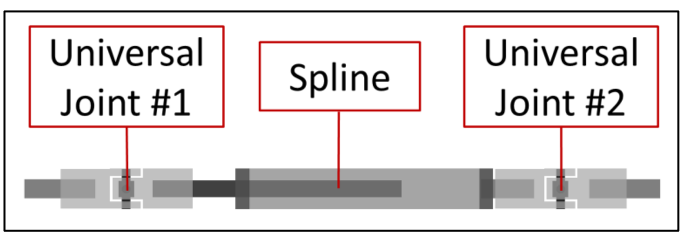

Figure 3.1: Pure moment loads were transferred to the test specimen through this shaft assembly, which includes a spline and two universal joints.

3.1. Compressive Follower-Load

As described in 2.3.4, a compressive follower-load could be applied to compress the FSU and simulate weight bearing in the spine. A conservative[1] standing load of approximately 440-N (100-lb) was applied to the test specimens while not significantly affecting the kinematics since the load is applied through the approximated axis of rotation. This initially seems like an easy task; however, it has been shown that the axis of rotation moves as the spine segment rotates, so the line of action of the follower-load must also move with the axis of rotation. The amount of this motion is likely specific to each test specimen and will vary with each spine and intervertebral disc geometry and biological composition. To ensure the follower-load line of action passed through the instantaneous axis of rotation (IAR), an active control feedback mechanism would need to be employed, thus significantly complicating the tests. No effort was made to reduce this source of error, but the line of action naturally moved in the same pattern as the IAR translated. Although the magnitude of movement was likely different for the IAR and the line of action, this difference was assumed to be insignificant.

A free-hanging weight was used to apply a compressive load on the test specimen. The weight was transmitted to the specimen through a pulley suspended by two wires that attached bilaterally to the upper potting fixture, as shown in **Figure 3.2**. For a single-level FSU, application of the compressive follower-load is fairly simple, but it becomes more complicated with the increased number of spinal segments in the test specimen. For example, a single-level FSU (e.g. L3-L4) test specimen is easier to apply a compressive follower-load than a multi-level

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[1] Conservative in comparison to the average male

FSU test specimen (e.g. L1-L5). The lordotic curvature of the lumbar spine requires that the vertebral column is not a purely vertical column, and the follower-load must pass through the IAR of each FSU. This requires that the line of action must be adjusted for each level, which significantly increases the difficulty and setup.

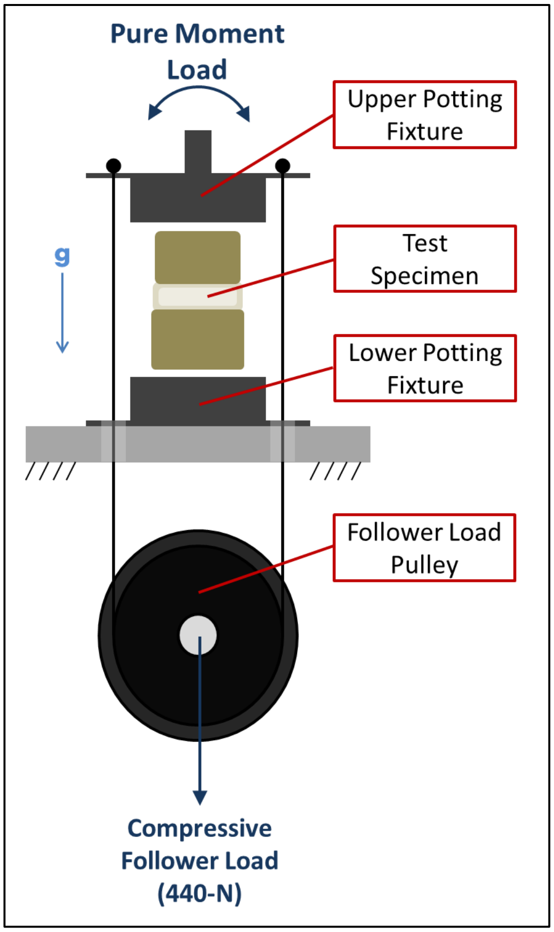

Figure 3.2: Schematic of follower-load assembly

3.2. Motion Tracking

Motion of the test specimen was captured through two methods: real-time and post-hoc digital image analysis. Real-time motion of the segment was approximated by tracking the steps of the stepper-motor, which provided the pure-moment load. Assuming the drive shaft and test specimen both rotated the same amount and about the same axis, this provided a near-instantaneous approximation of the rotation. With relatively small loads applied (torque < 8-Nm) through the drive shaft, it is safe to say that the rotational deflection caused in the drive shaft is negligible when compared to the rotation of the spine segment; however, any slipping in the joints would be a significant source of error. In order to minimize potential error, the standard for position tracking in biomechanics involves post hoc image analysis.

Post hoc analysis of digital pictures (Basler Vision Technologies; Exton, PA) more accurately captured the motion of the test specimen by directly measuring three-dimensional position of high-contrast markers that were rigidly attached to the upper potting fixture, which secured the superior vertebra. Using the three-dimensional position data, the position of the instantaneous axis of rotation could be calculated, as well as the amount of rotation experienced about the three modal axes.

3.3. Environmental Chamber

Near 100% relative humidity (RH) was achieved using a steam vaporizer (humidifier), and verified via two methods: a wireless hygrometer, and the "dip method." The dip method involved dipping a long, thin clear piece of acrylic (that remained the same temperature as the environmental chamber) into the environmental chamber. If the humidity in the air condensed on the strip of acrylic, it was determined to be at or near 100% RH. The temperature was modulated by increasing or decreasing the volumetric flow rate of compressed cold air into the environmental chamber.

Through the same heat transfer mechanism that the "dip method" was based on, the temperature and humidity difference between the inside and outside of the environmental chamber caused the viewing glass to fog, thus preventing the motion tracking cameras to view the tracking matrix. This problem was resolved by applying an anti-fog gel (JAWS Spit; USA), and heating the outside surface of the viewing glass with a blow dryer.

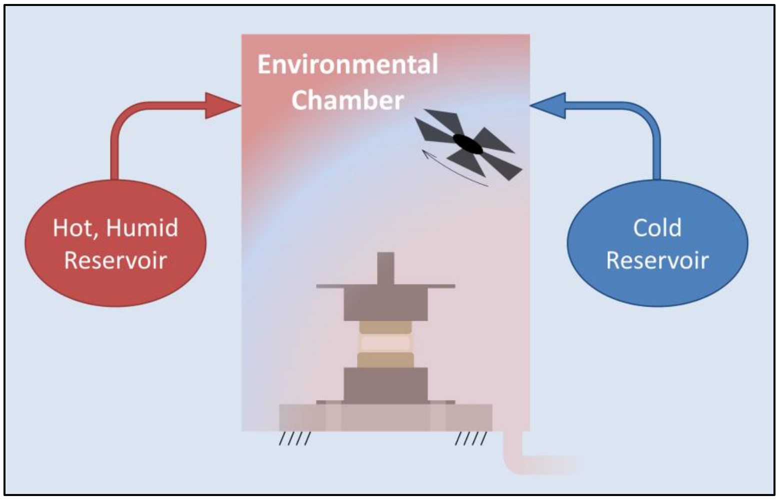

Figure 3.3: Schematic of the environmental chamber

The desired temperature was achieved by regulating the amount of hot, humid air and cold air that was pushed into the environmental chamber. The hot, humid air was provided by a steam vaporizer/humidifier, and cold air was provided via an air compressor. Since cold air vapor naturally holds less water than hot air when saturated, room temperature saturated air was cooled down from the body temperature saturated environment. Temperature and humidity were assumed to be constant in the space surrounding the test specimen as the air was continuously circulated throughout the environmental chamber via a 3-inch, 12-VDC cooling fan (**Figure 3.3**).

3.4. Loading in All Modal Directions

The spine simulator is capable of loading the test specimen in axial-rotation, flexion-extension, and lateral-bending. This is accomplished by changing the orientation of the test specimen within the environmental chamber, or by changing the orientation and position of the motor and shaft assembly. For flexion-extension and lateral bending tests, the motor and shaft assembly remained secured to the test table while the test specimen was rotated 90 degrees about its vertical axis. For axial-rotation tests, the motor and shaft assembly were secured to the elevated platform above the testing chamber. A schematic of this concept is shown in **Figure 3.4**.

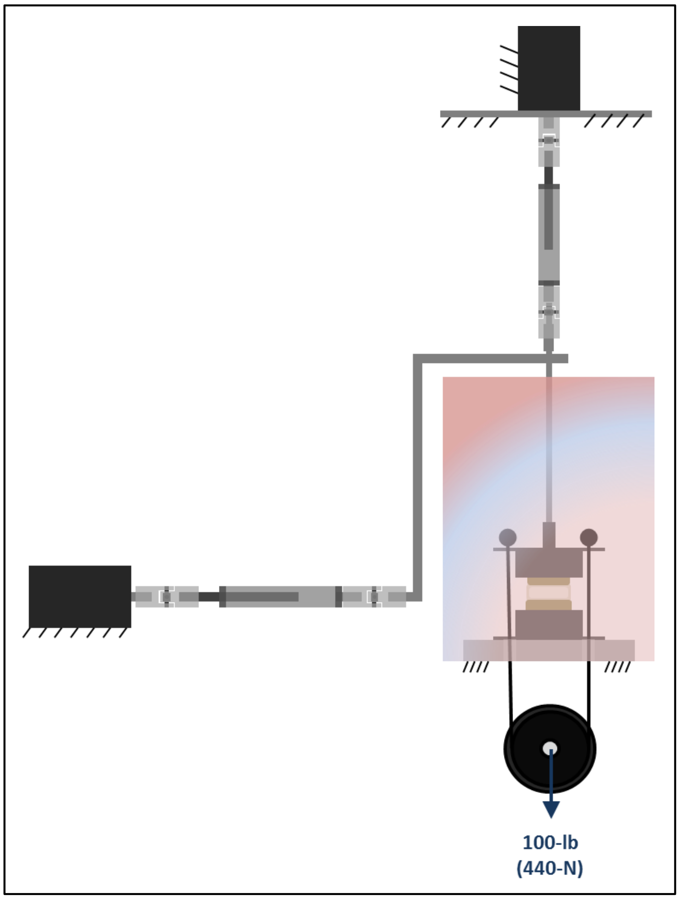

Figure 3.4: Schematic representation of the spline, environmental chamber, and compressive follower-load, all integrated to allow testing in axial-rotation, flexion-extension, or lateral-bending.

3.5. User Interface

The simulator control system (*National Instruments Corporation*, *LabVIEW 2009*) used a torque sensor (*Transducer Techniques*; Temecula, CA) and the rotary encoder (Section 3.2) to micro-control a high-torque stepper motor (*Automation Direct*; Atlanta, GA) and output real-time torque-rotation data. The digital pictures used for motion tracking were triggered and time-stamped to be synchronized with the corresponding torque-response.

The control program allows selection of a control method (torque-control or position-control) as well as specifying the loading limits (e.g. 7.5 N-m for torque-controlled, or 10 degrees rotation for position controlled tests), and the loading type (stepwise or dynamic loading). For detailed information about the control program, please refer to Appendix A.

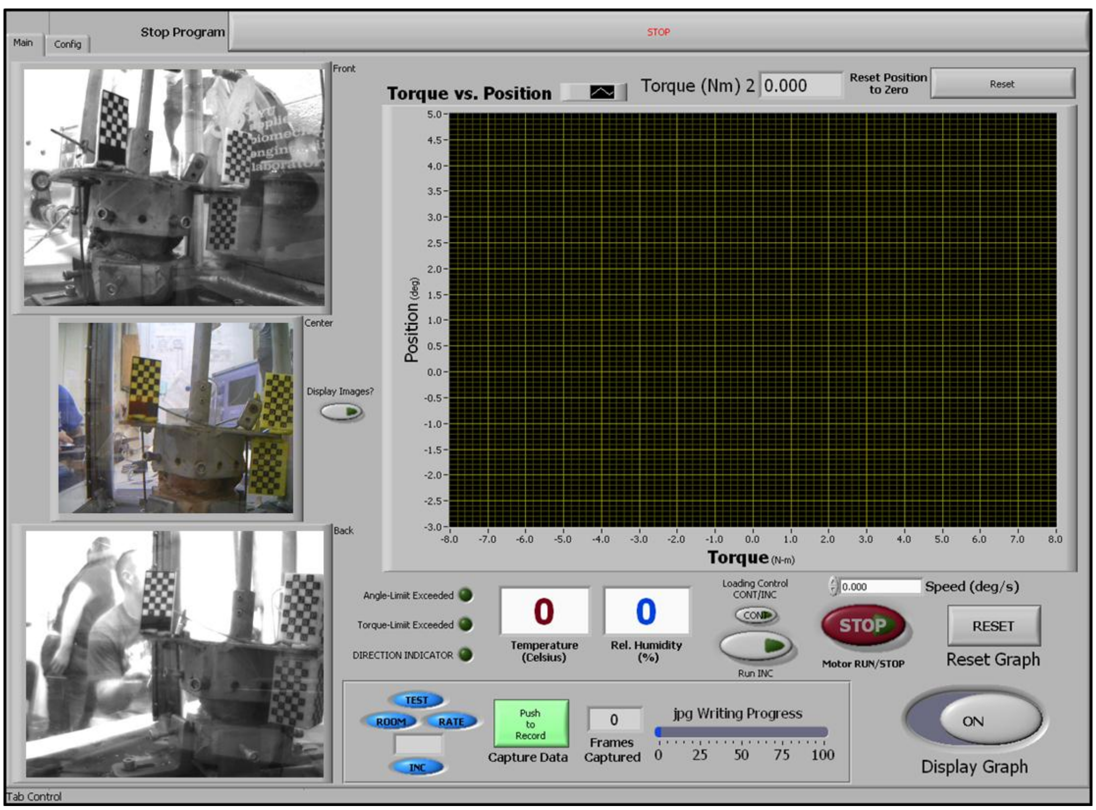

Figure 3.5: Front-panel of the *LabVIEW*® control program.

The user may also specify the loading-rate (e.g., 1 deg/sec). The most common method of dynamic loading involves loading at a continuous rate as determined by the time-derivative of position (i.e., $rate \doteqdot [deg/sec]$). Other common methods of applying a dynamic load involves loading at a continuous rate as determined by the time-derivative of torque (i.e., $rate \doteqdot [Nm/sec]$), along with a frequency based rate (i.e, $rate \doteqdot [cycles/sec]$), such that the entire torque-rotation response is a complete cycle. The spine tester is not currently programmed to allow applying dynamic loads with the latter two methods, although it could be upon a few changes. It was determined that applying the load at a continuous rate of torque is unsustainable since the neutral zone would be mired. The neutral zone, which rotates through large degrees of rotation with little torque input, might require large rotational velocities and accelerations (first- and second-order time derivative of position), which further complicates the analysis due to effects of viscoelasticity. A frequency-based approach also allows for large rotational velocities and accelerations; while a frequency-based approach is more physiologically relevant, current engineering analysis methods incorporate the time-derivative of position. For this reason, the author suggests applying loads at a continuous rate as determined by the time-derivative of position (i.e., $rate \doteqdot [deg/sec]$).

3.6. Final Design

The final design incorporated all the above mentioned components used for spine biomechanics tests. A schematic of the integrated components is shown in **Figure 3.6**, with the completed prototype shown in **Figure 3.7**. Detailed information, including the drawing package and the control program documentation, can be found in Appendix A.

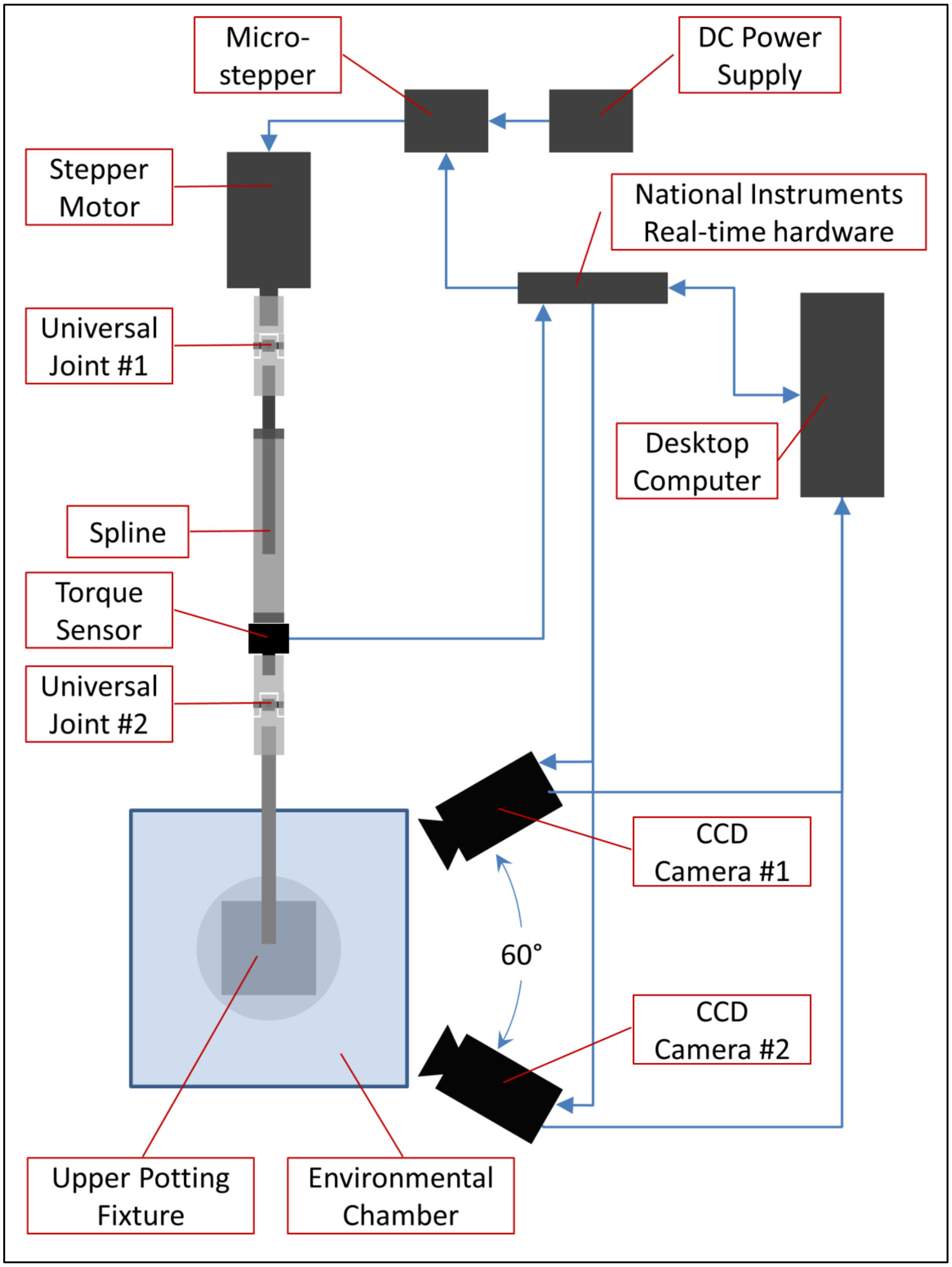

Figure 3.6: MASSUCE Schematic of integrated components.

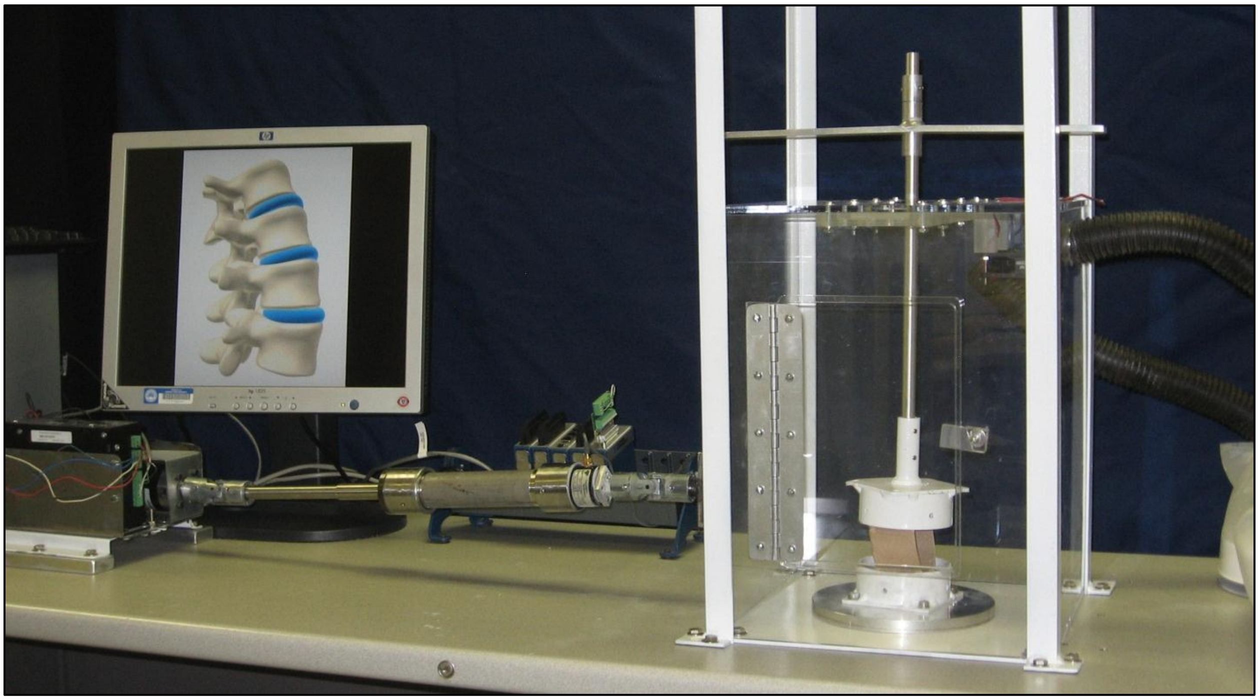

Figure 3.7: MASSUCE Final Design

4. METHODS[2]

4.1. Introduction

Many improvements have been implemented recently with spine biomechanics testing to better mimic *in vivo* conditions; however, testing methodologies remain rather obscure and vary between researchers, which reduce the ability of researchers to directly compare testing results as the physical testing methods often alter the observed results. Other sources of potential error include specimen preparation, statistical setup, and data analysis. Thorough reporting of the methods and procedures used during testing is essential for reproducing similar results and allowing other researchers to explain discrepancies in results; this explanation is only possible, however, if the effects of different testing methods is known. This chapter outlines the methods used during biomechanical analysis of the lumbar specimens.

4.2. Statistical Design of Experiments

Prior to testing, a statistical design of experiments was setup to randomly test and target the effects of the various test conditions. The order of the tests was carried out according to the associated *SLEDT* number, which is of the form

$$S.L.E.DD - DD.TTT - TTT.$$

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[2] Portions of this chapter have been submitted for publication in *Spine.*

SLEDT is an acronym to identify the test specimen and testing conditions, according to Table 4.1. Each spine (*S*) was divided into 2-3 FSUs, which were assigned a number based on the lumbar segment (*L*). The SL portion identified a specific FSU test specimen and was used to randomly assign the order the FSU would be tested. The remaining numbers (i.e., "*EDT*") were determined using a random number generator and the sequencing table (Table 4.2), which defined the correlation of the number and the test condition.

Table 4.1: The SLEDT number identifies the test specimen and the order of the tests

#	Definition	Explanation
S	Spine	1-digit number (1-8) specifies the spine of the test specimen
L	Lumbar Level	1-digit number (1-3) specifies the lumbar spine segment of the specimen
E	Environmental Temperature	1-digit number (1-2) specifies which temperature is tested first
D	Modal Loading Direction	2-part, 2-digit number (1-3) specifies the 1st and 2nd loading directions* at the 1st and 2nd testing temperatures
T	Loading-Type or Follower-load	2-part, 3-digit number (1-2) specifies the loading-type or follower-load of the 1st test for each loading direction at the 1st and 2nd testing temperatures

Notes:
* The 3rd loading direction is the direction that had not yet been tested

The progression of the performed tests was also nested in the SLEDT number (see **Figure 4.1**) as the number changed in such a way to reduce the experimental error and rapidly complete the experiments, thus maintaining the specimen integrity. As shown in Table 4.1 and Table 4.2, the numbers for *E*, *D*, and *T* refer to multiple tests on the same FSU (which is defined by the SL#). All the tests on a particular FSU were performed sequentially so that all potential combinations for *E*, *D*, and *T* were completed before *S* or *L* changed (i.e., another FSU was not tested until after all possible tests were completed with the one FSU). Likewise, to maintain specimen integrity of a particular FSU, all loading-type or follower-load tests (*T*) occurred at a particular temperature (*E*) and loading direction (*D*) in sequence. Stepwise tests always had follower-load on; follower-load analysis was only performed after stepwise loading tests were complete. Both environment temperatures simulated near 100% relative humidity. Dynamic analysis was always performed last, in FE, with a compressive follower-load on.

$$S.L.E_1.\underbrace{D_2D_1}_{c}-\overbrace{D_2D_1}^{a}.\underbrace{T_3T_2T_1}_{d}-\overbrace{T_3T_2T_1}^{b}$$

a. Loading-directions D_1 and D_2 at temperature E_1.
b. Loading-type or follower-load test T_1, T_2, and T_3, at loading-directions D_1, D_2, and D_3 at temperature E_1.
c. Loading-directions D_1 and D_2 at temperature E_2.
d. Loading-type or follower-load test T_1, T_2, and T_3, at loading-directions D_1, D_2, and D_3 at temperature E_2.

Figure 4.1: The SLEDT number is segmented into the ordering sequence as outlined here.

The sequencing of the tests only required one heat/cool cycle of the test specimen, so all three loading directions were performed at one temperature (room or body temperature) before heating (or cooling) to another temperature. The loading-type and/or follower-load (*T*) were sequentially changed within each loading direction and temperature.

The *T* value consisted of three analysis phases: *stepwise-loading*, *follower-load*, and *dynamic-loading*. Stepwise-loading consisted of the first six FSUs tested (see Section 4.4) and was always performed with the follower-load on. The follower-load and dynamic-loading analysis phases were performed on all the remaining FSUs. The dynamic-loading analysis phase was always performed last, with the follower-load on, and only in the flexion-extension loading direction. An example of a given SLEDT number, and the order of the tests generated from the number, is presented in Table 4.3.

Table 4.2: SLEDT sequencing table used to determine the order of the spine biomechanics testing. The spine were identified according to the tissue number assigned by *Science Care*®.

#	(S) Spine	(L) Lumbar Level	(E) Environment Temperature	(D) Modal Loading Direction	(T) Loading-Type/ Follower-load
1	S091199	L1-L2	Body (~37°C)	Axial-Rotation (AR)	Stepwise Analysis (1.5-Nm steps of 45-secs)
2	S090647	L3-L4	Room (~20°C)	Flexion-Extension (FE)	Continuous Control (1-deg/sec)
3	C091351	L5-S1		Lateral-Bending (LB)	Follower-load ON
4	C100115				Follower-load OFF
5	C070369				Dynamic Analysis (1/4–14-deg/sec)
6	C090519				
7	C091292				
8	S100589				

Table 4.3: Example expansion of how the SLEDT number defines the order of tests, using SLEDT#3.1.2.23–21.112–121, for the follower-load analysis. Each test is performed on SL# 3.1, which identifies the test specimen as the L1-L2 FSU of spine C091351, as shown in Table 4.2.

Order	SLEDT	EDT Defined
1	*3.1.2.1.1*	*Room Temperature, Axial-Rotation, Follower-load ON*
2	*3.1.2.1.2*	*Room Temperature, Axial-Rotation, Follower-load OFF*
3	*3.1.2.2.2*	*Room Temperature, Flexion-Extension, Follower-load OFF*
4	*3.1.2.2.1*	*Room Temperature, Flexion-Extension, Follower-load ON*
5	*3.1.2.3.1*	*Room Temperature, Lateral-Bending, Follower-load ON*
6	*3.1.2.3.2*	*Room Temperature, Lateral-Bending, Follower-load OFF*
7	*3.1.1.3.2*	*Body Temperature, Lateral-Bending, Follower-load OFF*
8	*3.1.1.3.1*	*Body Temperature, Lateral-Bending, Follower-load ON*
9	*3.1.1.2.1*	*Body Temperature, Flexion-Extension, Follower-load ON*
10	*3.1.1.2.2*	*Body Temperature, Flexion-Extension, Follower-load OFF*
11	*3.1.1.1.1*	*Body Temperature, Axial-Rotation, Follower-load ON*
12	*3.1.1.1.2*	*Body Temperature, Axial-Rotation, Follower-load OFF*

4.3. Specimen Preparation

Special care was taken to maintain the integrity of the specimen before and during testing. Specimen preparation and testing followed strict protocols, which are similar to those of current researchers [16, 23, 36, 37, 50-52, 54, 56, 80-83]. Full human lumbosacral spines (T12-S5) with no known spinal disorders were obtained from an accredited tissue bank and cleaned of all extraneous soft tissue, leaving the intervertebral disc, spinal ligaments, and facet capsules intact [43, 59, 84-87]. The lumbosacral spine was further segmented into single-level FSUs ranging from L1-L2 to L5-S1 segments. The specimen was frozen soon after excision, stored at -20°C, and sprayed with phosphate buffered saline (PBS) at five-minute intervals during dissection to maintain hydration [28, 32, 46]. The number of freeze-thaw cycles was minimized to avoid degradation [54, 56].

Figure 4.2: A single-level human lumbar FSU is secured in the environmentally controlled chamber in preparation for biomechanical testing at body temperature and 100% humidity. The environmental chamber can sustain near 100 % RH and either body temperature or room temperature.

Prior to testing an individual FSU, it was removed from the freezer and allowed to thaw at room temperature overnight (approximately 12-14 hours). The distal ends of the segment (i.e., the superior region of the superior vertebra and the inferior region of the inferior vertebra) were potted using a two-part polyester resin (Bondo 265, 3M; St. Paul, MN) after being superficially dried by blotting with paper towels to allow better adhesion of the resin and the vertebra. The purpose of potting is to allow better attachment between the test specimen and the spine tester by increasing the contact surface area with the abnormal geometry of the vertebra. Following potting, the test specimen was equipped with the upper and lower potting fixtures of the spine tester. These potting fixtures are then secured in the environmental chamber with the inferior vertebra fixed and the bending moments were applied to the superior vertebra (Figure 4.2).

The environmental chamber maintained near 100% relative humidity at either room temperature (20±3˚C) or body temperature (37±3˚C). To verify sufficient time to acclimate the specimen to the testing temperature, a thermocouple was inserted into the center of the disc of a T12-L1 segment during a warm-up/cool-down cycle. This preliminary study determined that the specimen required 20 minutes to reach 38°C from 21.5°C and 43 minutes to cool down from 40°C to 21.5°C. Based on this test, one hour of heating (room-to-body temperature) or cooling (body-to-room temperature) was determined to be sufficient time between tests conducted at different temperatures to allow the specimen to reach equilibrium temperature with the testing environment.

4.4. Physical Testing

A 440-N compressive follower-load was applied to the segment with the line of action through the FSU axis of rotation [23, 39, 65, 88]. The placement of the follower-load was iteratively calibrated to the axis of rotation by measuring the difference in starting torque with and without the follower-load and constraining this value to ±0.3-Nm. After the testing specimen attained equilibrium temperature with the environment, the FSU was preconditioned for a minimum of 20 cycles of ±7.5-Nm [6, 7, 8], until the torque-rotation response was consistently tracking the same path. Before capturing data, the FSU ran through another three-cycle conditioning routine, after which multiple cycles were recorded.

4.4.1. Temperature and Follower-load Tests

Biomechanical tests were performed using the flexibility method on 21 single-level FSUs obtained from 8 lumbar spines. Each test was performed using a continuous-speed loading-rate of 1-deg/sec, and each specimen was tested in axial-rotation, flexion-extension, and lateral-bending, with and without a compressive follower-load, at both room temperature (20±3˚C) and body temperature (37±3-˚C). These varied test conditions resulted in approximately 200 separate torque-rotation response curves available for paired analysis of temperature (body versus room), follower-load (ON versus OFF), and loading direction.

While the order of the tests was randomly selected (see 4.2), the test specimen was only heated (or cooled) once during the process, so all possible tests at a specific temperature were performed sequentially, then all the same tests were randomly performed at the other temperature. Likewise with loading direction: all possible loading direction tests were randomly performed sequentially for the specified temperature before changing the setup for another loading direction. This was done to reduce the number of heat-cool cycles for the specimen. It also reduced the experimental error for the follower-load analysis by not changing the test setup between the paired testing conditions (follower-load ON/OFF).

4.4.2. Loading-rate and Loading-type Tests

Dynamic loading was performed on the same 21 lumbar FSUs as those used for the temperature and follower-load tests (Section 4.4.1), but was limited to a single loading direction—flexion-extension. 11 FSUs were tested at body temperature, and 10 FSUs were tested at room temperature. Data was obtained for up to 19 torque-rotation tests for each FSU at various continuous-speed loading-rates ranging from ¼- to 14-deg/sec, and each test was performed with a compressive follower-load. This included multiple control-group tests using a continuous-speed loading-rate of 1-deg/sec, and resulted in 263 observations to determine any dependence on temperature and rate of dynamic loading.

The quasi-static, stepwise response was obtained from 6 lumbar FSUs tested in each temperature and loading direction with a compressive follower-load. Each segment was loaded at 1-deg/sec in 1.5-Nm load-increments [80], with a hold of 45 seconds per increment, up to a maximum torque-limit of ±7.5-Nm, as illustrated in **Figure 2.6**. A control-group test using a continuous-speed loading-rate of 1-deg/sec was also performed in each test configuration for each FSU. Each FSU was tested at room temperature and body temperature in axial rotation, flexion-extension, and lateral bending. This resulted in 72 observations to determine the effect of temperature, loading direction, and stepwise loading on the flexibility of the FSU.

4.5. Data Analysis

Segmental rotations in each of the primary modes of loading were computed from the 3D kinematic data, as described in Section 3.2, and synchronized with the torque response at the respective rotation. Typical with spine-biomehcanics, the torque-rotation corve is represented on a graph with the horizontal axis representing the applied torque and the vertical axis representing the observed motion. This method of plotting results in a nonlinear, sigmoidal response, such that maximum rotations approach a horizontal asymptote with larger magnitude loads. This method of plotting data is also opposite from the normal plotting techniques for engineering, where the load (torque) is commonly represented on the vertical axis and the displacement (rotation) is commonly represented on the horizontal axis. Nevertheless, it also works well for the curve used to model the torque-rotation response.

4.5.1. Curve Fitting

The rotation of the upper vertebra was calculated with respect to the fixed lower vertebra, and the flexibility parameters were determined numerically from the torque-rotation curve after fitting an equation to the data. The torque-rotation response of the segment was centered about the range of motion (ROM) and fit with a dual-inflection-point Boltzmann (DIP-Boltzmann) equation, which is of the form

$$\theta = \frac{ROM}{2} \cdot \left[1 - \frac{1}{1+e^{\alpha_1 \cdot (T-m_1)}} - \frac{1}{1+e^{\propto_2 \cdot (T-m_2)}}\right], \qquad (4\text{-}1)$$

where θ is the segment rotation (dependent variable), ROM is the segment range of motion, T is the applied torque (independent variable), m_1 and m_2 identify the inflection points, and α_1 and α_2 are associated with the rate of change of the exponential at m_1 and m_2.

The DIP-Boltzmann equation was selected to model the torque rotation response due to its ability to track the non-symmetric, nonlinear sigmoid shape with a high coefficient of determination $\left(\overline{R^2} = 0.99\right)$ for a wide range of spine segment specimens. The DIP-Boltzmann parameters have physical meaning with respect to the torque-rotation response and enable objective, repeatable calculation of common flexibility parameters (e.g., range of motion, neutral zone, neutral-zone stiffness, and hysteresis). By using separate DIP-Boltzmann equations to model the torque-rotation response (1 upper (unloading→loading) and 1 lower (unloading→loading)) for each test, the full nonlinear, and viscoelastic response of the segment can be captured. An example of a typical curve-fit, depicting the calculated flexibility parameters, is shown in Figure 4.4.

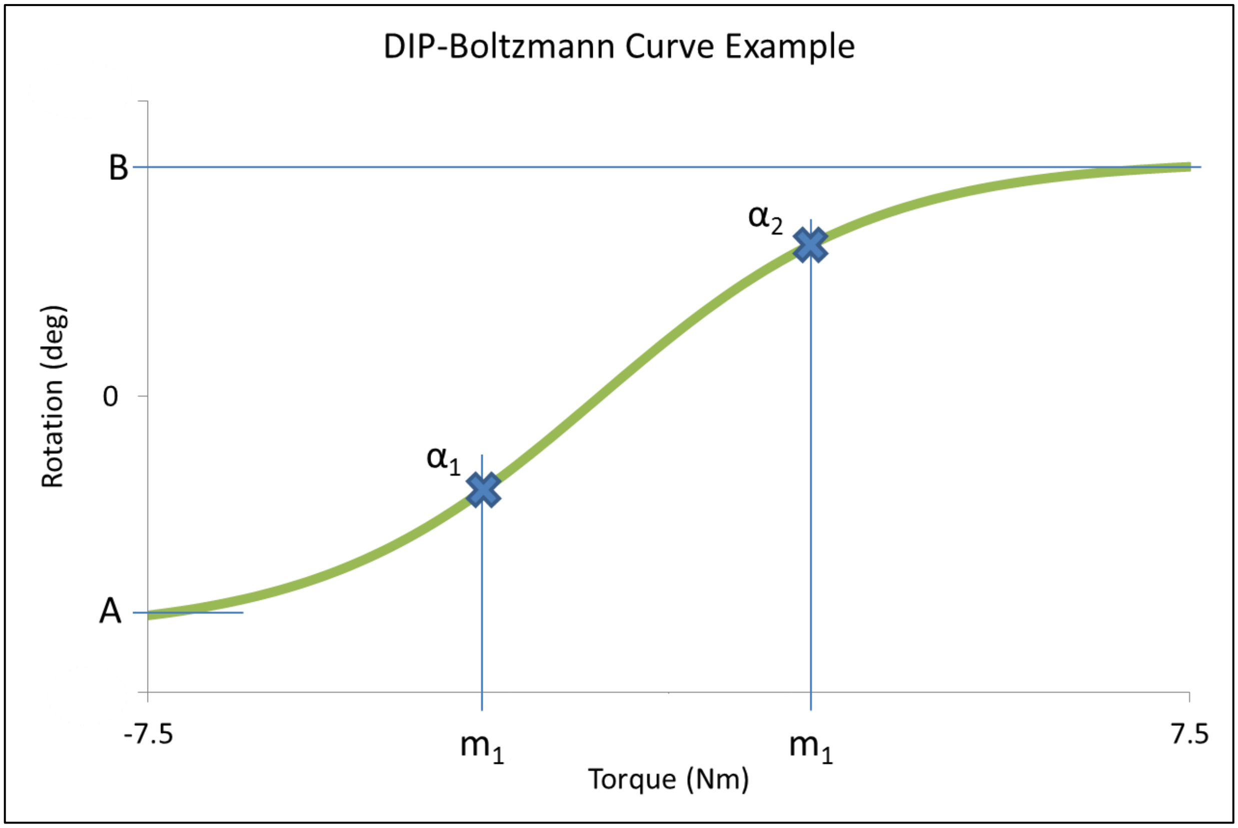

Figure 4.3: DIP-Boltzmann equation parameters hold physical meaning for the nonlinear sigmoid profile. A and B are the minimum and maximum rotations of the segment, m1 and m2 are the horizontal locations of the inflection point(s), while α1 and α2 are the approximate slopes of the exponential curve. ROM = |B-A|.

The flexibility parameters (ROM, NZ, K, and H) describe the viscoelastic torque-rotation response and were calculated according to the method described in Table 4.4. As the response was largely dependent on the individual FSU, the effects of a compressive follower-load, altered temperature, loading-type, or loading-rate were expressed as a dimensionaless value. The statistical design of experiments (Section 4.2) was created to mitigate the procedural variation of the experiment and target the effects that are directly caused by the altered testing conditions (e.g., follower-load, temperature, loading-rate), but the subject-specificity was removed through non-dimensionalization, as described next, and the necessity of this procedure is exemplified in Section 5.2.2.

Table 4.4: Flexibility parameters of a spinal segment and the method of calculation

Parameter	Definition	Calculation
ROM	Range of motion (deg). The amount of segmental rotation experienced during testing	The difference between the maximum and minimum rotations $ROM = \theta_{max} - \theta_{min}$
NZ	Neutral zone (deg). A portion of the ROM where small changes in load result in large changes in rotation	Determined numerically as the maximum rotation difference between the upper and lower DIP-Boltzmann curves for an applied torque $NZ = (\theta_{UPPER} - \theta_{LOWER})_{max}$
K	Stiffness of neutral-zone (Nm/deg). The amount of torque required to cause one degree of rotation within the near constant-slope neutral-zone region	The inverse of the average upper and lower curves' slope (flexibility) within the neutral-zone $K = \left[\frac{1}{2} \cdot \left(\frac{d\theta_{NZ}}{dT}_{UPPER} + \frac{d\theta_{NZ}}{dT}_{LOWER}\right)\right]^{-1}$
H	Hysteresis (Nm). The horizontal spread of the upper and lower torque-rotation curves within the neutral zone	The difference in average torque within the neutral zone, between the upper and lower DIP-Boltzmann curves $H = (\overline{T_{NZ}})_{LOWER} - (\overline{T_{NZ}})_{UPPER}$

4.5.2. Non-dimensionalization

A common problem with testing biological tissue is the large degree of variation between tests, which often complicates the ability to draw conclusions from the test results. This variation may be attributed to several factors (e.g., original location of biological tissue, test setup/method), but a method was necessary to target a particular effect of interest (e.g., temperature, loading-rate) while increasing the transparency of other sources of variation.

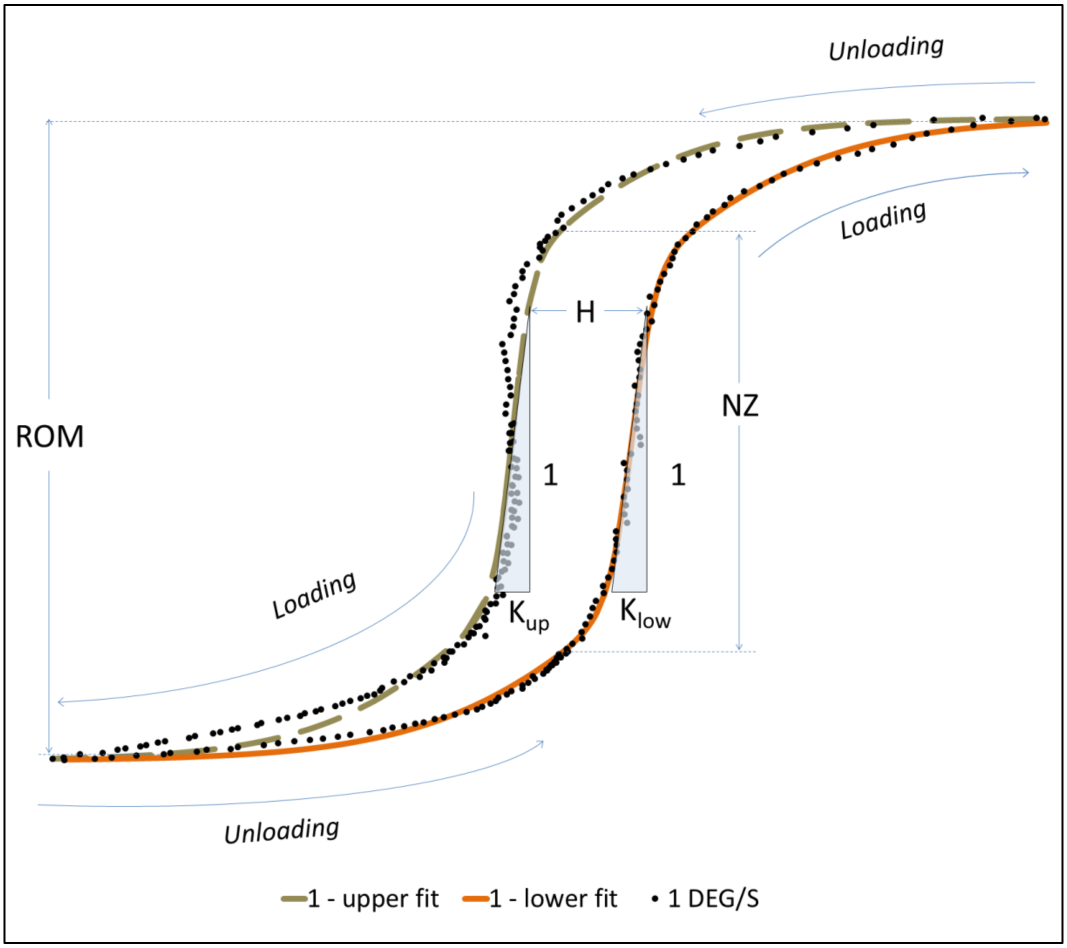

Figure 4.4: A typical curve fit (R^2_{upper} = 0.968, R^2_{lower} = 0.998) of the DIP-Boltzmann curve of the torque-rotation response of a lumbar FSU. Common flexibility parameters (ROM, NZ, K, H) are shown with their visual depictions. Also included are the "unloading" and "loading" descriptors of the torque response.

Non-dimensionalization involves calculating the ratio of a particular parameter (e.g., ROM, NZ, α_{1upper}, m_{2lower}) with the same parameter obtained during the control test, therefore spanning the effect of interest with at least two different settings and creating dimensionless parameters.

A minimum number of two tests are required for non-dimensionalization—a single control test and one (or more) analysis test(s). Ideally, the dimensionless value obtained determines the consequence of altering the effect of interest, according to Table 4.5. As the ideal situation is rarely realized, this should be performed on multiple test specimens, which should result in a normal distribution of dimensionless values. Statistical analysis of a large dataset of dimensionless parameters will further increase understanding of the effect of interest.

Table 4.5: Non-dimensionalization of parameters reveals the consequence of altering a particular effect

Dimensionless Value	***Consequence (The altered state of the effect of interest…)***
> 1	increases the parameter
= 1	has no effect on the parameter
< 1	decreases the parameter

Reporting deterministic statistics is sufficient and non-dimensional analysis should result in the same (or similar) conclusions for an infinitely large dataset as the variations should cancel out. However, non-dimensionalization yields accurate results that more easily express the consequence of a particular effect.

4.5.3. Statistical Analysis

Extensive statistical analysis was performed on the variables for the DIP-Boltzmann fit involving a mixed-model analysis of variance (MANOVA) blocking on the individual FSU-temperature test subject. The test subject was considered a random variable, where the mean data across all subjects tested was not relevant, but rather the variance within each test. The test specimen was considered a random variable, where the mean data across all tests was not relevant, but rather the variance within each specimen. Statistical significance is reported as $p<0.05$, with $\alpha=0.05$. A repeated-measures t-test was also performed, corresponding to the loading-rate and temperature.

For analysis of temperature and follower-load, the random FSU variable was crossed with temperature and follower-load because all possible combinations were performed on each specimen. For stepwise loading, the random FSU subject was crossed with temperature and rate because the same rates and temperatures were randomly performed on each specimen. For the dynamic loading tests, the random FSU effect was crossed with rate and nested with temperature because all rates were performed on each subject but did not include tests at both body temperature and room temperature.

Custom statistics code was developed using the SAS® programming language and software from *Statistical Analysis System (SAS Institute Inc.*; Cary, North Carolina, USA) to analyze the DIP-Boltzmann and flexibility parameters for every test performed on each FSU. The DIP-Boltzmann data was loaded following curve-fitting and used to numerically calculate the flexibility parameters, create boxplots, compile descriptive statistics, and perform MANOVA, predictions, Bland-Altman analysis, and more. For detailed information about the developed software, see Appendix D.

5. NON-INTUITIVE CHANGES IN SPINE BIOMECHANICAL RESPONSE WITH SPECIMEN TEMPERATURE AND COMPRESSIVE LOAD EFFECTS[3]

5.1. Introduction

The purpose of this study was to quantify and analyze the temperature-dependent changes in the biomechanical response of the lumbar spine with, and without, a compressive follower-load. Mechanical testing of viscoelastic materials has shown a correlation of the material stiffness with temperature and bending-rate [2, 27-29]. Whereas no studies had been found that justify flexibility testing of biological tissue at any temperature other than the native body temperature, the vast majority of researchers reported their results at room temperature [17, 20, 29, 31-40, 49-54], which may significantly alter the mechanical behavior from the *in vivo* state. Subsequently, this same dependency was believed to occur with the intervertebral disc (IVD) and spinal ligaments, which would affect the mechanical response of a functional spinal unit (FSU) and skew the data used to create accurate spine models and devices. Researchers had only recently begun including a compressive follower-load during ex vivo lumbar flexibility testing. The compressive load was expected to stiffen the spinal segment, and thus decrease range of motion, as the increased load compresses the intervertebral disc and effectively stabilizes the

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[3] Portions of this chapter have been submitted for publication in *The Spine Journal.*

spinal segment [39, 63-68]. Room temperature testing was also expected to decrease the segmental range of motion in all directions of loading.

5.2. Results

5.2.1. Statistics Overview

A MANOVA test was performed on the entire dataset to determine which parameters were significantly affected by the specimen temperature (Temp) and compressive follower-load (Load), as detailed in Table 5.1. An analysis of these p-values enabled reasonable assumptions to be made about which effects most prominently affected the torque-rotation response of the test specimen. The conclusions that were derived from this analysis include:

1. Loading direction (Dir) largely affected the flexibility and the quality of motion (QOM), as it significantly affected every DIP-Boltzmann parameter (α_{1upper}, m_{1upper}, α_{2upper}, m_{2upper}, α_{1lower}, m_{1lower}, α_{2lower}, m_{2lower}) as well as each of the flexibility parameters (ROM, NZ, K, H).
2. Subject-specific behavior was apparent as the FSU significantly affected all flexibility parameters and several of the DIP-Boltzmann parameters.
3. Temperature effects (Temp) were commonly significant for the relative slope of the exponentials (i.e., α_{1upper}, α_{2upper}, α_{1lower}, α_{2lower}).
4. A compressive follower-load (Load) also seemed to dominate the slope of the exponentials, along with several flexibility parameters.

As loading direction largely affected the flexibility of the spine, the dataset was separated and a targeted MANOVA was performed for each loading direction (Table 5.2), therefore decoupling the loading direction with the various test effects. In each loading direction, the common significant effect was again the FSU, therefore signifying a large degree of specimen specific behavior. The DIP-Boltzmann parameters were not significantly affected by testing temperature; however, the compressive follower-load appeared to consistently affect the relative slope of the exponential (i.e., α_{1upper}, α_{2upper}, α_{1lower}, α_{2lower}), while only occasionally appearing significant with the location of the inflection points (m_{1upper}, m_{2upper}, m_{1lower}, m_{2lower}).

Table 5.1: MANOVA of the DIP Boltzmann and flexibility parameters for the temperature and follower-load tests.

MANOVA	Upper DIP-Boltzmann				Lower DIP-Boltzmann				Flexibility Parameters			
Effect	α_1	m_1	α_2	m_2	α_1	m_1	α_2	m_2	**ROM**	**NZ**	**K**	**H**
Load	*		*			*	#	*	#		#	#
Temp	*		*		*		*			*		*
FSU	*	*				*		*	#	*	*	#
Dir	#	*	*	#	#	#	*	*	#	#	#	#

Note: Blank cells represent no statistical significance. * represents p<0.05; # represents p<0.0001.

Testing temperature and a compressive follower-load significantly affected all flexibility parameters in axial rotation. In flexion extension, the compressive follower-load affected ROM, NZ, and H, while the testing temperature was not significant for any parameter. In lateral bending, testing temperature was significant for NZ along with the slope of the exponentials, while the compressive follower-load was significant for all the flexibility parameters, the slope of the exponentials, and locations of the upper curve inflection points.

A comprehensive testing protocol was performed in this study, where each test specimen was loaded in the same loading directions, with and without a compressive follower-load, and tested at the same testing temperatures, as outlined in 4.4.1. These procedures have several benefits for analysis; however the most useful benefit is likely that a straightforward descriptive analysis of the results is possible.

Table 5.2: Mixed-model Analysis of the DIP Boltzmann Coefficients from Temperature and Follower-load Tests.

Targeted MANOVA		Upper DIP-Boltzmann				Lower DIP-Boltzmann				Flexibility Parameters			
Direction	Effect	α_1	m_1	α_2	m_2	α_1	m_1	α_2	m_2	ROM	NZ	K	H
Axial–Rotation	Load	*		*		*		*		#	#	#	*
	Temp		*							#	#	*	*
	FSU	*	*				*	*	*	#	#	#	*
Flexion–Extension	Load	*				*	*		*	*	#		#
	Temp												
	FSU	#	#		#		#		#	#	*	#	*
Lateral–Bending	Load	#	*	#	*	#		#		#	#	#	#
	Temp	*		*		*		*			*		
	FSU				*		*		*	#	*	*	*

Note: Blank cells represent no statistical significance. * represents p<0.05; # represents p<0.0001.

5.2.2. Descriptive Analysis

A descriptive analysis involves quantifying the effects using standard statistics that describe the dataset (e.g., mean and standard deviation). The magnitude of the specific effect is quantified in Table 5.3 and graphically displayed in Figure 5.1 using several boxplots. Testing temperature is specified in the "Temp" column as "BODY" for body temperature tests, and "ROOM" for room temperature tests. The compressive follower-load is specified in the "Load" column as "L" (for loaded) for the compressive load applied to the test specimen, and "nl" (for not loaded) for no compressive load applied.

The compressive follower-load was determined to significantly affect most of the flexibility parameters in all loading directions, with various conclusions made involving the effects of testing temperature for specific loading directions. In axial rotation, testing without a compressive follower-load showed increased range of motion and neutral zone, and decreased neutral-zone stiffness and hysteresis, at both room and body temperature. In flexion extension, testing without a compressive follower-load increased range of motion, and decreased neutral zone, neutral-zone stiffness, and hysteresis, at room and body temperature. Lateral bending tests without a compressive follower-load increased range of motion, and decreased neutral-zone stiffness and hysteresis at room and body temperature; however, neutral zone decreased at body temperature and increased at room temperature.

Table 5.3: Temperature and Compressive Follower-load Flexibility Parameter Summary

Dir	Temp	Load	ROM	NZ	K	H
Axial-Rotation	BODY	L	4.424 (2.004)	0.708 (0.415)	3.108 (1.957)	1.660 (0.689)
		nl	7.666 (2.489)	1.386 (0.526)	1.016 (0.576)	1.132 (0.448)
	ROOM	L	3.460 (2.130)	0.414 (0.303)	4.529 (2.942)	1.202 (0.438)
		nl	5.647 (2.472)	0.918 (0.549)	1.648 (1.054)	1.028 (0.371)
Flexion-Extension	BODY	L	9.811 (4.635)	2.985 (1.525)	0.973 (1.124)	1.810 (1.043)
		nl	12.25 (4.478)	1.748 (0.667)	0.498 (0.218)	0.698 (0.294)
	ROOM	L	9.572 (4.578)	3.575 (3.040)	0.795 (0.973)	1.292 (0.681)
		nl	11.80 (3.980)	1.860 (0.996)	0.512 (0.374)	0.710 (0.326)
Lateral-Bending	BODY	L	9.921 (6.704)	2.529 (2.077)	1.877 (1.910)	2.158 (0.591)
		nl	12.17 (3.587)	2.042 (0.623)	0.591 (0.189)	1.056 (0.499)
	ROOM	L	8.509 (4.753)	2.246 (2.264)	1.820 (1.880)	1.922 (0.650)
		nl	11.17 (3.193)	5.840 (3.029)	0.318 (0.493)	0.911 (0.473)

Analysis of the effects of temperature also showed significant changes on the flexibility parameters. In axial-rotation, room temperature testing resulting in decreased range of motion, neutral zone, and hysteresis, and increased neutral-zone stiffness, when compared to body temperature. In flexion-extension, room temperature testing resulted in increased segmental range of motion and neutral zone, and decreased neutral-zone stiffness, with and without the applied compressive follower-load; room temperature testing showed that hysteresis decreased with a compressive follower-load and increased without a compressive follower-load. For lateral bending tests, range of motion and hysteresis decreased with room temperature testing, with and without a compressive follower-load. Room temperature testing with a compressive follower-load decreased segmental neutral zone and neutral-zone stiffness, when compared to the same tests at body temperature; however, room temperature tests without a compressive follower-load increased neutral zone and neutral-zone stiffness when compared to the same tests at body temperature.

As each specimen was tested in the same directions, temperatures, and loading conditions, reporting deterministic statistics is sufficient and non-dimensional analysis should result in the same (or similar) conclusions if the dataset is large enough for a normalized distribution of the flexibility parameters, such that random effects cancel each other upon averaging the data. Nevertheless, it was beneficial to non-dimensionalize (Section 4.5.2) the data to reduce the random effects and specimen specific behavior, as determined by the prominent FSU effect in the targeted MANOVA (Section 5.2.1). This effect was reduced through non-dimensionalization, which resulted in two additional datasets from targeting the two effects—follower-load (nD-Load dataset) and temperature (nD-Temp dataset)—for each loading direction.

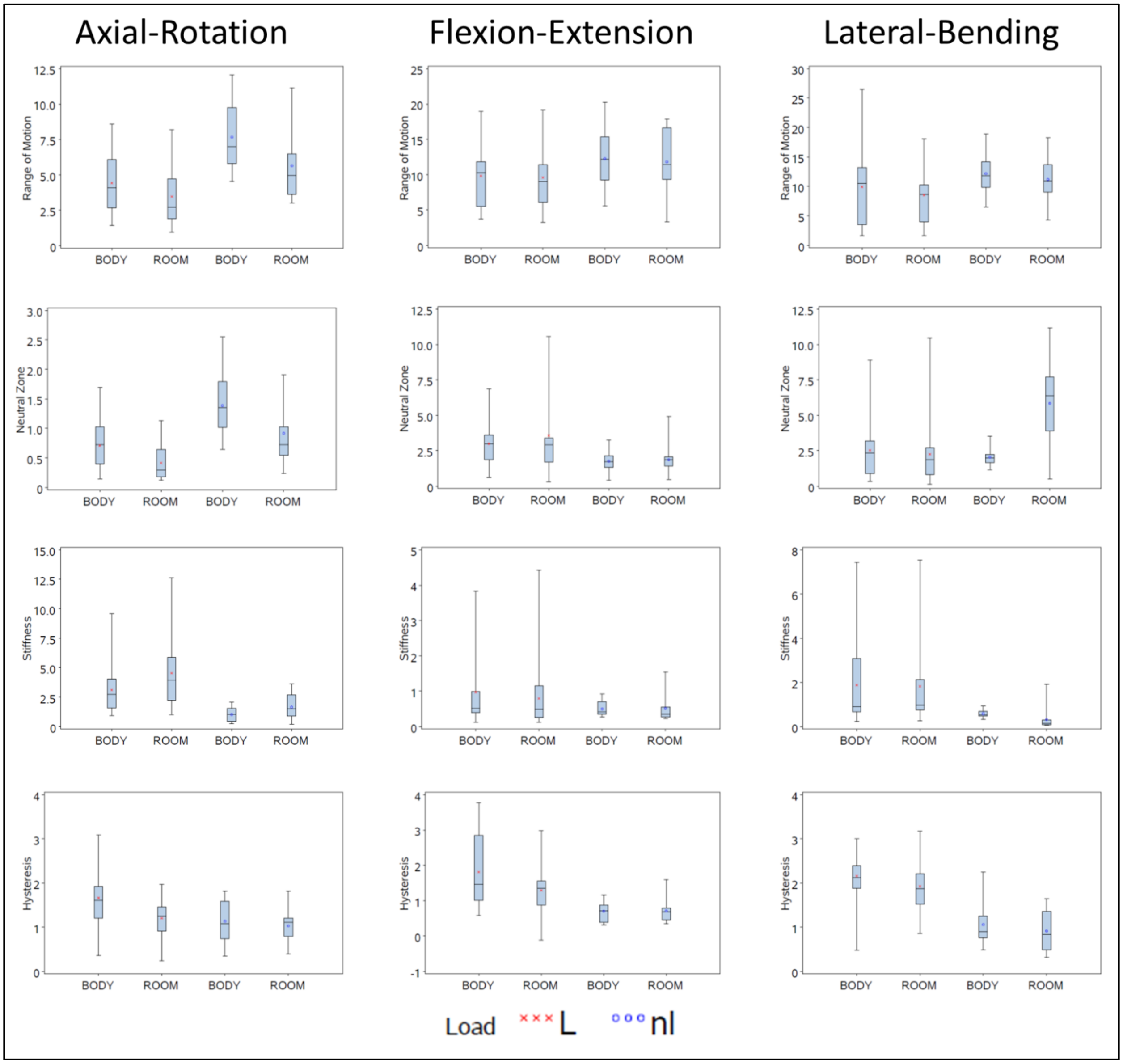

Figure 5.1: Boxplots of flexibility parameters show the effects of specimen temperature and a compressive follower-load. Horizontal line in box represents the mean value, with the upper and lower edges at the 75th and 25th percentile; error lines represent two standard deviations. The temperature conditions are listed as "BODY" and "ROOM" for body and room temperature tests. Tests performed with a compressive follower-load (denoted "L") are the 2 boxes on the left, while tests performed without a compressive follower-load (denoted "nl") are the 2 boxes on the right, of each plot.

5.2.3. Non-dimensional Analysis of Specimen Temperature

Targeted temperature effects were obtained using dimensionless flexibility parameters by calculating the ratio of a particular flexibility parameter observed at the non-physiological temperature (i.e. room temperature) with respect to that observed at the physiological temperature (i.e., body temperature), as explained in Section 4.5.2. The MANOVA of the non-dimensionalized data shows that specimen specific behavior was eliminated, as shown in Table 5.4. Room temperature testing significantly affected the flexibility parameters in axial-rotation and the slope of the exponentials in lateral-bending.

Table 5.4: Mixed-model analysis of dimensionless DIP-Boltzmann and flexibility parameters for the targeted analysis of the effect of testing at room temperature compared to body temperature.

nD-Temp MANOVA		Upper DIP-Boltzmann				Lower DIP-Boltzmann				Flexibility Parameters			
Direction	Effect	α_1	m_1	α_2	m_2	α_1	m_1	α_2	m_2	ROM	NZ	K	H
Axial-Rotation	Temp		*		*					#	#	#	#
	FSU												
Flexion-Extension	Temp							*					
	FSU												
Lateral-Bending	Temp	*		*		*		*					
	FSU												

Note: Blank cells represent no statistical significance. * represents p<0.05; # represents p<0.0001.

The averaged dimensionless parameters that quantify the changes in the flexibility parameters are provided in Table 5.5. In axial-rotation, room temperature tests significantly decreased ROM, NZ, and H, and increased K both with and without a follower-load. Flexion-extension and lateral-bending tests showed approximately stable flexibility parameters.

Table 5.5: Summary of dimensionless flexibility parameters used for analysis of temperature effects (RT/BT) with (L) and without (nl) a compressive follower-load.

Dir	*Load*	*ROM*	*NZ*	*K*	*H*
AR	L	0.757 (0.164)	0.639 (0.252)	1.398 (0.434)	0.777 (0.194)
	nl	0.819 (0.144)	0.733 (0.179)	1.259 (0.286)	0.917 (0.222)
FE	L	1.158 (0.612)	1.302 (0.972)	1.000 (0.533)	0.927 (0.318)
	nl	1.145 (0.436)	1.137 (0.399)	0.988 (0.695)	1.033 (0.474)
LB	L	1.014 (0.419)	1.007 (0.585)	1.117 (0.567)	0.911 (0.262)
	nl	0.998 (0.352)	1.502 (1.181)	1.081 (1.140)	0.886 (0.657)

5.2.4. Non-dimensional Analysis of Compressive Follower-load

The MANOVA of the non-dimensionalized data shows that specimen specific behavior was eliminated, as shown in Table 5.6. Targeted compressive load effects were obtained using dimensionless flexibility parameters by calculating the ratio of a particular flexibility parameter observed at the non-physiological state of loading (i.e., without a compressive follower-load) with respect to that observed at the physiological loading state (i.e., with a compressive follower-load), as explained in Section 4.5.2.

Analysis of the compressive load effects showed a more straightforward effect when comparing results from testing without a compressive follower-load to the results obtained from testing with a compressive follower-load. In all loading directions, testing without a compressive follower-load significantly increased ROM and decreased H at both room and body temperature. NZ significantly increased in axial-rotation and lateral-bending tests, yet decreased in flexion-extension. K significantly decreased in axial-rotation.

Table 5.6: Mixed-model analysis of the dimensionless DIP-Boltzmann and flexibility parameters for the targeted analysis of the effect of testing without a compressive follower-load.

nD-Load MANOVA		Upper DIP-Boltzmann				Lower DIP-Boltzmann				Flexibility Parameters			
Direction	Effect	α_1	m_1	α_2	m_2	α_1	m_1	α_2	m_2	ROM	NZ	K	H
Axial-Rotation	Load	#	*	#	*	*		#	*	#	#	#	*
	FSU												
Flexion-Extesnion	Load				*	*	*	*	*	#	#		*
	FSU												
Lateral-Bending	Load	*	#	*	#	*	*	#	*	#	*		#
	FSU												

Note: Blank cells represent no statistical significance. * represents p<0.05; # represents p<0.0001.

Table 5.7: Summary of dimensionless flexibility parameters used for analysis of compressive load effects show the effect of testing without a compressive follower-load compared to testing with a compressive follower-load.

DIR	*Temp*	*ROM*	*NZ*	*K*	*H*
AR	BODY	1.686 (0.242)	2.264 (1.651)	0.432 (0.106)	1.096 (1.258)
	ROOM	1.906 (0.520)	2.173 (0.767)	0.383 (0.094)	1.098 (1.213)
FE	BODY	1.261 (0.240)	0.563 (0.255)	1.157 (0.699)	0.524 (0.358)
	ROOM	1.261 (0.419)	0.693 (0.409)	1.189 (0.649)	-.005 (1.902)
LB	BODY	2.248 (0.983)	1.865 (1.518)	0.411 (0.279)	0.476 (0.184)
	ROOM	1.816 (0.706)	2.501 (2.225)	0.944 (1.532)	0.580 .528)

5.3. Discussion

Several aspects of *ex vivo* testing of biological tissue continue to improve, while accounting for various influential factors. Spinal flexibility is significantly altered by the sometimes competing effects of increased temperature and compressive follower-load. The present work quantifies these effects, allowing interpretation of previous testing results in the context of more accurate physiological conditions.

5.3.1. Specimen Temperature

Lower temperatures normally decrease the compliance of elastic and viscous material. A similar effect was expected for viscoelastic materials; however, this was not congruent in all the loading directions. The expected behavior was observed in axial rotation, which showed room temperature testing significantly decreased range of motion, neutral zone and hysteresis, and significantly increased stiffness, but unexpected results were obtained in flexion-extension and lateral-bending. Lower temperatures were expected to decrease the rate of stress-relaxation and, therefore, decrease the amount of hysteresis. This was true for all loading directions (as shown in Table 5.5), although significant changes occurred only in axial-rotation. Despite the insignificant behavior in flexion-extension and lateral-bending, these results confirm viscoelastic behavior of the functional spinal unit.

One possibly significant factor that was overlooked when formulating the hypothesized behavior was the FSU geometry. Flexibility testing in lateral-bending may be constrained geometrically by facet contact at the extremes of motion, such that pure lateral-bending is not possible. Thus, due to this geometric limitation, significant changes in range of motion due to temperature are less likely to be observed in lateral-bending. Flexion-extension results showed that room temperature testing results in increased range of motion and neutral zone, and decreased stiffness, when compared to the body temperature tests.

A logical explanation derived from these results is that body temperature testing dehydrated the test segment, and therefore reduced the compliance of the segment. Further analysis is necessary to confirm this; however, this was also mentioned as a concern by other researchers [79]. It is possible however, that the geometric limitations reduce the magnitude of the effects of temperature, such that temperature may rarely significantly affect the torque-rotation response of the spinal segment in flexion-extension and lateral-bending. As the majority of spine arthroplasty devices only bend in flexion-extension and lateral-bending, room temperature testing would provide a relevant approximation through much easier testing procedures.

5.3.2. Compressive Follower-load

Testing with a compressive follower load, however, appears to provide significant improvements to spine biomechanics testing; however, despite the more physiologic loading that it provides, application of a compressive follower-load introduces an avenue of variation due to user error in applying the follower-load. The torque-rotation response may be very sensitive to the location of the follower-load. The author recommends performing flexibility tests to determine the repeatability of testing with a compressive follower-load and also to measure the sensitivity of the tests to follower-load placement.

The sensitivity of a loading direction to the follower-load can be examined from a mechanics perspective. The follower-load will induce a moment on the FSU anytime it is not acting through the instantaneous axis of rotation. The shortest distance between the line of action of the follower-load and the axis of rotation is the moment-arm. The ratio of this moment arm to the area moment of inertia will directly affect the mechanics of the FSU in a positive correlation, such that a larger ratio signifies larger sensitivity to the follower-load. Depending on the geometry of the lumbar intervertebral disc, which may be approximated as an ellipse with the major axis extending laterally and the minor axis extending anteroposteriorly, the relevant area moment of inertia will be smaller for flexion-extension than for lateral-bending. Therefore, flexion-extension loading is expected to be more sensitive to the placement of the compressive follower-load. Axial-rotation loading occurs about an axis that is parallel with the line of action of the compressive follower-load and cannot be compared to flexion-extension and lateral-bending, which occur about axes that are perpendicular to the follower-load line of action.

6. CHARACTERIZATION AND PREDICTION OF RATE-DEPENDENT VISCOELASTICITY[4]

6.1. Introduction

Temperature, loading-rate, and compressive pre-load are known to affect the biomechanics of the functional spinal unit (FSU) [26-32], however the magnitude of these effects has not been comprehensively reported in literature. The bulk of reported spine biomechanics tests were performed at room temperature rather than body temperature [17, 20, 29, 32-40], which may cause the mechanical behavior to be significantly altered. Various rates of loading have been used in biomechanics studies [13, 14, 17, 22, 25, 40, 41], however a systematic investigation of the effects of altered loading-rates is currently lacking. Additionally, most of the existing studies that have addressed either temperature or rate dependence were conducted before the adoption of the compressive follower-load as a standard for testing.

Spinal biomechanical studies enhance our understanding of the healthy, injured, and aging spine [20, 21]. These studies also provide target behavior for medical devices and validation criteria for analytical spine studies [13, 14, 16, 17, 21-25]. The flexibility method [37, 51] has become a standard for testing spine biomechanics and involves applying a pure moment as the resulting motion is measured. Common flexibility parameters used to evaluate and

[4] Portions of this chapter have been submitted for publication in *Spine.*

compare biomechanical flexibility data from spinal studies include the segmental range of motion (ROM), neutral-zone stiffness (K), hysteresis (H), and various metrics for defining the “neutral zone” (NZ) where small changes in loading result in large changes in segmental motion [13, 14, 17, 18, 21, 33, 34, 56, 77-79].

The majority of researchers have recently adopted a dynamic spinal flexibility testing protocol that is continuous-speed with loading-rates that are *ad hoc* toward “very slow” [40, 57, 58]. Traditionally, spine researchers tested flexibility using a quasi-static, stepwise loading protocol, which involves applying the load in select increments of torque for a specified time period, therefore obtaining a pseudo-static response of the segment at the respective positions. Dynamic testing requires increased complexity of testing equipment (e.g., motors, control systems, data acquisition rates), however provides increased congruity with the in vivo kinesiology of the spine.

This study builds on past work by characterizing the effects of spine segment loading-rate while testing at body and room temperature with a compressive follower-load. All three primary modes of loading are investigated using both stepwise and dynamic flexibility testing. Flexion-extension flexibility is examined in substantially more detail by investigating 11 distinct loading-rates with a redundant testing protocol to ensure repeatability. Based on this data, we developed a stochastic model that accurately predicts the segmental flexibility of a lumbar spine segment at any rate within the physiologic range based on a single flexibility test.

6.2. Results

6.2.1. Statistics Overview

For stepwise loading analysis, each specimen was tested in all directions and all temperatures; therefore, reporting descriptive statistics is sufficient and non-dimensional analysis was not necessary to draw conclusions from the results. This, however, was not possible for the dynamic loading data as each test specimen was only tested at a single temperature setting. The MANOVA tests for the non-dimensional DIP-Boltzmann and flexibility parameters confirmed initial hypothesis while giving insight to draw further conclusions. Note that the DIP-Boltzmann parameters are often temperature-dependent and rarely affected by loading-rate, while the flexibility parameters are often affected by both temperature and rate.

Table 6.1: Table of p-values for dimensionless DIP-Boltzmann and flexibility parameters.

Data	Direction	Effect	Upper DIP-Boltzmann				Lower DIP-Boltzmann				Flexibility Parameters			
			α_1	m_1	α_2	m_2	α_1	m_1	α_2	m_2	ROM	NZ	K	H
Stepwise	Axial-Rotation	Rate						*			*	*	#	*
		Temp		#						*	#	#	*	
	Flexion-Extension	Rate	*			*					*	*		*
		Temp	*			*		*	*					*
	Lateral-Bending	Rate										*		
		Temp									*			
Dynamic	Flexion-Extension	Rate									#		#	#
		Temp		*	#	#			*		#	#	#	#

Note: Blank cells represent no statistical significance. * represents p<0.05; # represents p<0.0001.

Following analysis, a predictive model was created from the effects data of the various loading-rates for flexion-extension. Predicted values were calculated for segment range of motion, neutral zone, neutral-zone stiffness, and hysteresis, and compared to actual values using a Bland-Altman analysis [89, 90].

6.2.2. Stepwise Loading

Stepwise loading increased range of motion (ROM), neutral zone (NZ), and hysteresis (H), in all motion directions (Table 6.2) relative to continuous loading at 1-deg/sec (control). These results were statistically significant ($p<0.05$) for axial rotation at both room temperature and body temperature and flexion-extension at body temperature. Lateral-bending flexibility tests were almost unaffected between stepwise and continuous loading at 1-deg/sec. Neutral-zone stiffness (K) was not significantly different between stepwise and continuous loading at 1-deg/sec.

Specimen temperature (room temperature versus body temperature) significantly changed segmental flexibility in several aspects. Room temperature tests resulted in significantly decreased ROM, NZ, and H, in axial rotation, for both stepwise and continuous-speed (control rate) loading. Room temperature also significantly increased K in axial rotation but only for stepwise loading. Temperature effects were rarely significant in flexion-extension or lateral-bending (Table 6.2).

Table 6.2: The effect of stepwise loading (by temperature subset) and room temperature (by loading-type subset) for each motion direction is captured by calculating the dimensionless ratio of the flexibility parameters. All data is given as *mean (standard deviation)*, with statistical significance (p<0.05) denoted by an asterisk.

Stepwise Tests		Axial-Rotation				Flexion-Extension				Lateral-Bending			
Effect	Subset	ROM	NZ	K	H	ROM	NZ	K	H	ROM	NZ	K	H
Stepwise / Control	Room-Temp	1.214* (0.080)	1.832* (0.656)	0.893 (0.070)	1.619* (0.483)	1.125 (0.163)	1.420 (0.427)	1.005 (0.278)	1.401 (0.545)	1.084* (0.033)	1.261 (0.071)	1.130 (0.409)	1.277 (0.087)
	Body-Temp	1.372* (0.291)	1.961* (0.897)	0.739* (0.136)	1.447 (0.559)	1.306* (0.294)	1.362* (0.181)	0.814 (0.226)	1.164 (0.224)	1.040 (0.156)	1.549 (0.910)	1.238 (0.431)	2.181 (2.155)
Room Temp / Body Temp	Stepwise	0.687* (0.140)	0.535* (0.167)	1.449* (0.372)	0.736* (0.124)	0.974 (0.626)	1.503 (1.997)	1.169 (0.629)	0.770 (0.220)	0.804* (0.126)	0.770 (0.304)	1.125 (0.545)	0.862 (0.273)
	Control	0.762* (0.139)	0.614* (0.364)	1.171 (0.225)	0.685* (0.280)	1.101 (0.722)	1.312 (1.433)	0.989 (0.511)	0.692* (0.255)	0.801* (0.158)	0.964 (0.501)	1.216 (0.791)	1.288 (1.202)

6.2.3. Dynamic Loading

The dynamic loading data showed a trend of decreasing ROM and increasing K and H with increasing loading-rate, while NZ appeared to be constant (Table 6.3). These results confirm the statistics in Table 6.1, which shows that ROM is the only variable in the DIP-Boltzmann equation to be significantly affected by loading-rate for the dynamic loading data.

Table 6.3: Flexibility parameters of the dynamic loading tests in flexion-extension. The rate-dependent effect is expressed as the dimensionless ratio of the flexibility parameters. All data is given as *mean (standard deviation)*.

RATE (deg/sec)	Body Temperature (37°C)				Room Temperature (20°C)			
	ROM	NZ	K	H	ROM	NZ	K	H
0.25	1.07 (.04)	1.06 (.04)	0.96 (.11)	1.01 (.04)	1.03 (.01)	1.05 (.01)	0.96 (.06)	1.04 (.01)
0.5	1.05 (.04)	1.06 (.04)	0.96 (.05)	1.02 (.04)	1.01 (.01)	1.03 (.01)	0.98 (.06)	1.03 (.01)
1	1.00 (.01)	1.00 (.01)	1.00 (.01)	1.00 (.01)	1.00 (.01)	1.00 (.01)	1.00 (.01)	1.00 (.01)
2	0.96 (.05)	0.97 (.05)	1.03 (.06)	1.01 (.05)	0.99 (.01)	0.98 (.01)	1.05 (.05)	1.00 (.01)
4	0.91 (.07)	0.97 (.07)	1.10 (.08)	1.03 (.07)	0.98 (.01)	1.05 (.01)	1.04 (.05)	1.07 (.01)
6	0.91 (.07)	0.93 (.07)	1.13 (.10)	1.02 (.07)	0.97 (.02)	1.05 (.02)	1.08 (.09)	1.11 (.02)
8	0.91 (.08)	0.98 (.08)	1.14 (.11)	1.09 (.08)	0.97 (.01)	1.07 (.01)	1.11 (.24)	1.17 (.01)
10	0.89 (.08)	0.94 (.08)	1.15 (.08)	1.07 (.08)	0.97 (.02)	1.09 (.02)	1.10 (.20)	1.16 (.02)
12	0.89 (.09)	0.99 (.09)	1.13 (.10)	1.13 (.09)	0.96 (.03)	1.04 (.03)	1.10 (.14)	1.16 (.03)
14	0.89 (.09)	1.03 (.09)	1.15 (.10)	1.16 (.09)	0.96 (.04)	1.19 (.04)	1.11 (.10)	1.35 (.04)

6.2.4. Predictive Model

Based on the testing results, we hypothesized that changes in segmental flexibility due to loading-rate in the voluntary rand of loading-rates could be accurately modeled with a relatively simple scaling of the range of motion, which scales the DIP-Boltzmann equation. This is possible because the rate-dependent response is captured with the segmental ROM, while the curve shape (e.g., inflection points) depends on temperature and geometry, and remains constant when testing at the same temperature. Specifically, we hypothesized that upon obtaining a full set of DIP-Boltzmann parameters for a particular FSU at a given temperature from a dynamic-loading test at a single rate, the flexibility of the FSU can be predicted for any voluntary loading-rate (e.g., Figure 6.1). Using the same DIP-Boltzmann parameters (m_1, m_2, α_1, α_2) and the predicted range of motion (ROM_{pr}), the predicted values may also be calculated for the remaining flexibility parameters (NZ_{pr}, K_{pr}, H_{pr}) using the same methods described in Table 4.4 and Figure 4.4. This method was implemented through the process shown in Figure 6.2.

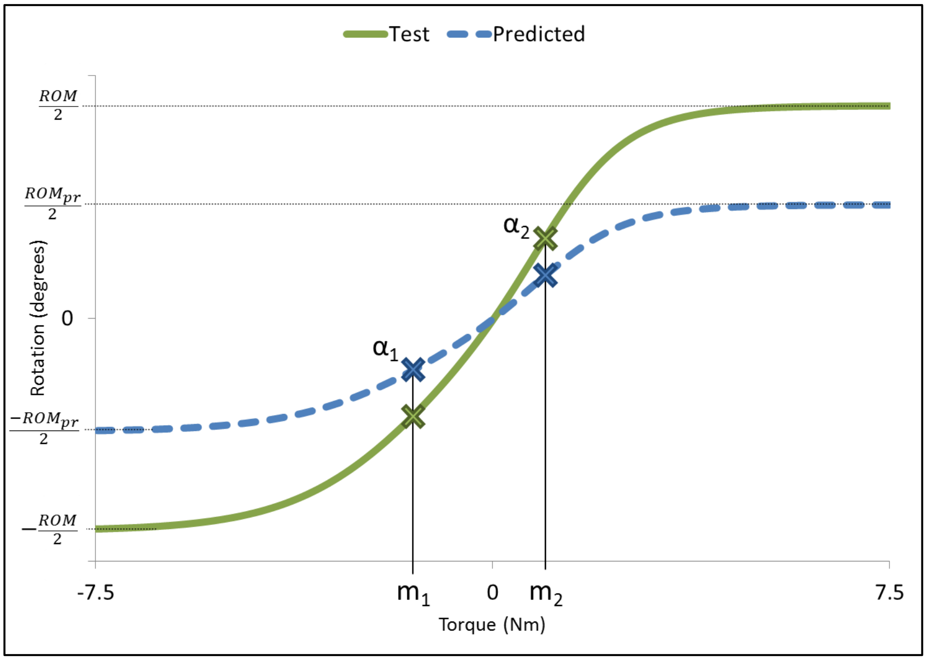

Figure 6.1: The DIP-Boltzmann curve obtained at one loading-rate may be used to predict the curve at another rate as the ROM is scaled, and all other parameters remain the same.

To test this hypothesis, an equation was created (below) to scale the observed ROM of a spine segment to the ROM that would be observed at various rates of loading. Using the normalized DIP-Boltzmann data, proportionality constants (Table 5, Figure 5) for predicting segmental range of motion were determined using a least-squares method. These proportionality constants were applied to predict the range of motion, according to

$$ROM_{pr} = \frac{C_{pr}}{C_{ref}} \cdot ROM_{ref}, \tag{6-1}$$

where ROM_{ref} is the range of motion observed during a flexibility test at a known loading-rate, and ROM_{pr} is the predicted range of motion at a different loading-rate. The C-values are temperature-specific, which proved to affect the segmental response (i.e., they are only valid for predictions within the same testing temperature). C_{pr} is the proportionality constant for the loading-rate of the desired predicted ROM, and C_{ref} is the proportionality constant at the loading-rate at which the data were obtained. Proportionality constants for any rates not listed (but within the range of reported rates) may be approximated using linear interpolation.

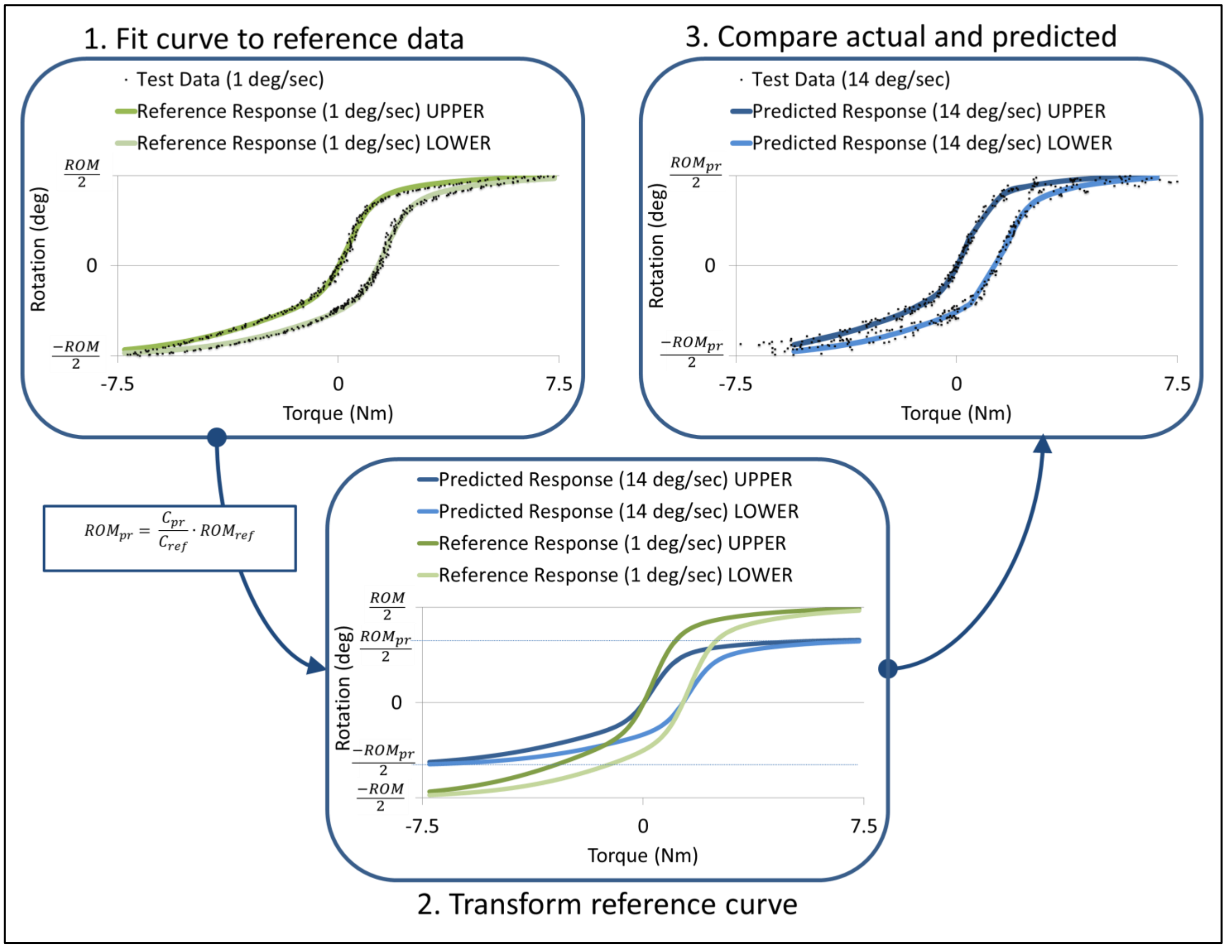

Figure 6.2: A torque-rotation curve obtained at one loading-rate was used to predict the curve at another rate, and compared to the actual response, through the process shown here.

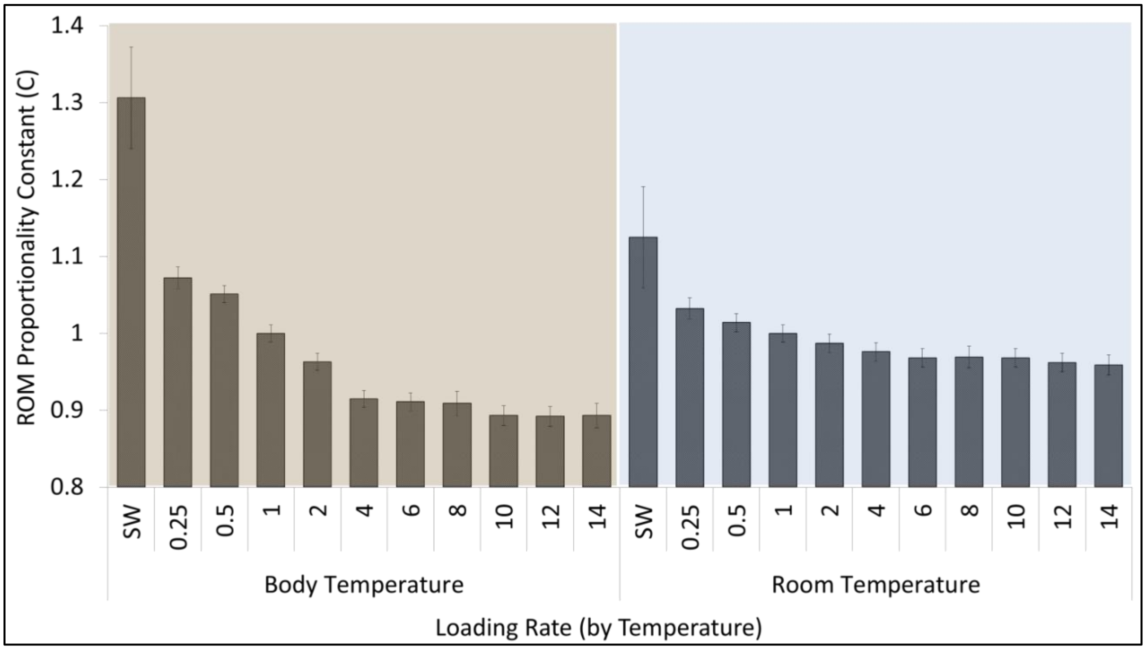

Figure 6.3: Predicted range of motion (ROM) proportionality constants are plotted against the loading-rate with predicted error lines shown, according to body temperature or room temperature.

Table 6.4: Range of motion proportionality constants scale the range of motion for a particular loading-rate.

Rate	C_{Body}	C_{Room}
SW*	1.306 (0.066)	1.125 (0.066)
0.25	1.072 (0.014)	1.032 (0.014)
0.50	1.051 (0.011)	1.014 (0.012)
1.00	1.000 (0.011)	1.000 (0.011)
2.00	0.964 (0.011)	0.987 (0.012)
4.00	0.915 (0.011)	0.976 (0.012)
6.00	0.911 (0.012)	0.968 (0.012)
8.00	0.909 (0.016)	0.969 (0.014)
10.0	0.893 (0.013)	0.968 (0.012)
12.0	0.892 (0.013)	0.962 (0.012)
14.0	0.893 (0.016)	0.959 (0.013)

Note: Values are shown as *proportional value (error)* according to testing temperature and loading-rate. *Stepwise (SW) predictions are presented for completeness only and were not included in the Bland-Altman analysis due to the large variation in the results due to stress relaxation.

Verification of the predictive value of the model was performed utilizing the entire dataset of flexiblity curves, which included 263 flexibility curves that were obtained from the 21 FSUs for 10 different loading-rates. Each curve, with its independent DIP-Boltzmann parameters, was used to predict the torque-rotation curve expected to be observed at each of the other recorded loading-rates, resulting in approximately 2,530 independent torque-rotation curves, from which all four segmental flexibility parameters were calculatedand compared to the parameter observed at the particular loading-rate to determine the accuracy of the prediction.

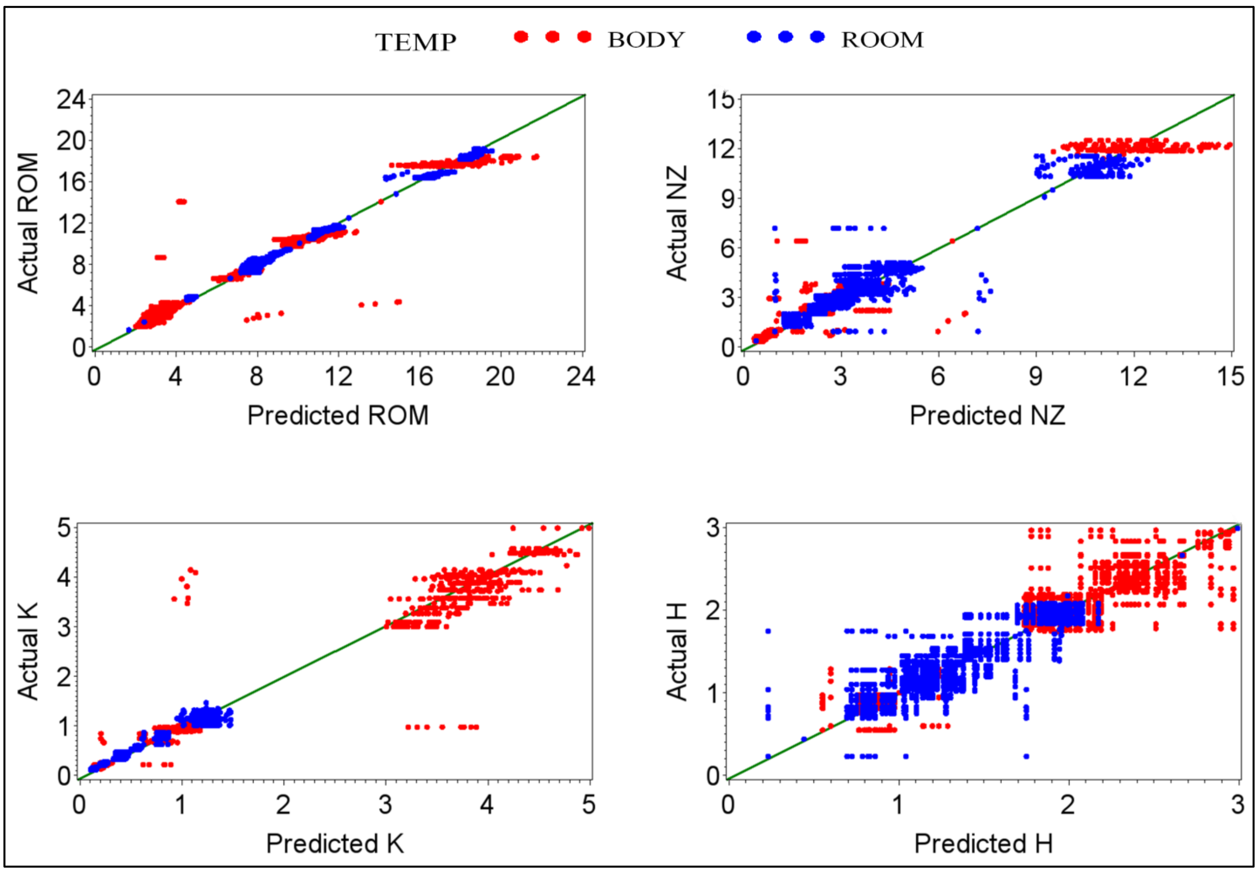

Figure 6.4: Actual versus predicted values are plotted for all (2530) predicted dynamic flexibility tests at all (10) loading-rates with the identity line for body (red) and room (blue) temperature for (a) range of motion (b) neutral zone (c) neutral-zone stiffness and (d) hysteresis.

As suggested by Bland and Altmann [89-91], the actual-versus-predicted values for range of motion, neutral zone, neutral-zone stiffness, and hysteresis, were plotted with the identity line in Figure 6.4. Each dot on each graph represents a comparison between the indicated parameter from an actual measured flexibility test with that predicted by the model. Conformity to identity shows how well the predicted values match the actual values. Thus a dot placed on the line y=x shows perfect agreement between the model prediction and the measured parameter. The coefficients of determination (R^2) for each parameter as compared with the identity line show strong correlation: 0.963 (range of motion), 0.951 (neutral zone), 0.956 (neutral-zone stiffness), and 0.852 (hysteresis).

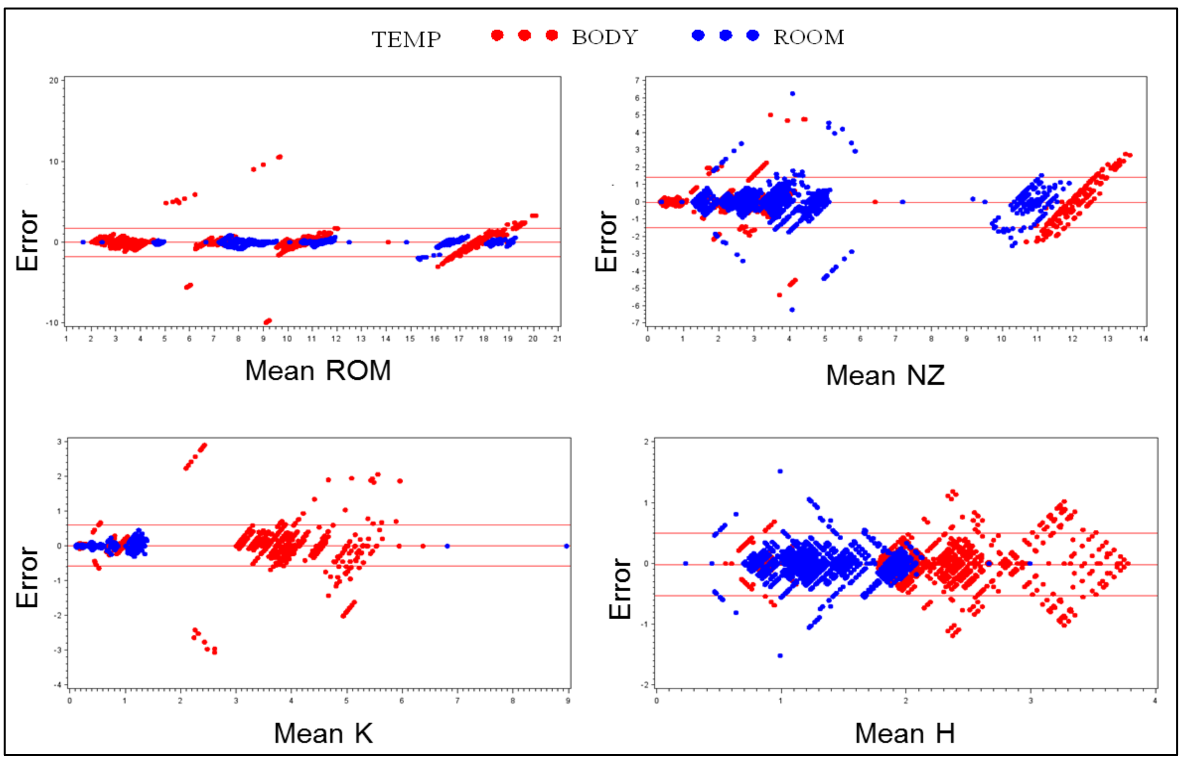

Figure 6.5: Bland-Altman analysis of comparing two methods shows good grouping of the mean values of the flexibility parameters while often constraining the error within a standard deviation (as represented by the red lines).

6.3. Discussion

The present work quantifies the variation in the lumbar spine flexibility with regards to testing temperature and loading rate. The observed changes in segmental flexibility were consistent with previously published data, however the present work provides a comprehensive picture of these effects. The results have application to both numerical modeling and medical device design, where viscoelastic effects have often been ignored, presumably due to lack of validation data.

The predictive model is a novel contribution that allows for straightforward approximation of spinal segment torque-rotation behavior at rates spanning the range of voluntary motion based on the determination of the response at a single rate. Interestingly, changes in neutral-zone stiffness, neutral zone, and hysteresis were found to be dependent variables with respect to changes in segmental range of motion. The Bland-Altman analysis confirms that the model has a high accuracy for the included datasets at both body and room temperature.

There are several limitations of the predictive model. More work is required for cross-temperature estimations, if such a relation is possible. Proportionality constants for quasi-static stepwise loading are provided for completeness, although it was observed that stepwise tests exhibited much higher variations in viscoelastic stress-relaxation as compared to dynamic loading for both body temperature and room temperature tests (Table 3). Additionally, the work could be strengthened through validation of the predictive model on an independent database of rate-dependent flexibility tests; however no such database currently exists and reserving samples from the present portion for validation purposes would have limited the strength of the stochastic model.

The applied boundary conditions (+/- 7.5 Nm of applied torque) were chosen according to the bulk of lumbar spine flexibility tests reported in the literature[13, 14, 24, 25, 70, 79, 80, 83, 85, 92]. The authors expect that the reported ROM proportionality constants are reasonable approximations for applied torques that are beyond the neutral zone of the specimens, however very low magnitude flexibility testing may not scale identically. Verification of this expectation remains a topic for future work. Similarly, extrapolation of proportionality constants beyond the measured range of testing rates (¼- to 14-deg/sec) has not yet been explored. Specifically, the authors caution against using these relationships at very high rate-testing (e.g., injury biomechanics applications) until more data has been collected at those rates.

In summary, this study captures the viscoelastic, torque-rotation response of the human lumbar spine across the range of voluntary spinal motion. The work provides a context for the large amount of cadaveric spine testing data that has been acquired under distinct loading rates and temperatures in the presence of a compressive follower load. We anticipate that the predictive model of rate-dependent spinal flexibility will enhance understanding of spinal biomechanics over a broader range of common daily activities.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Summary of Contributions

This work resulted in the development, construction, and validation of a custom spine simulator, which has been labeled as the “MASSUCE”. The spine simulator allowed testing multiple-level spine specimen with a compressive follower-load in a temperature- and humidity-controlled environment while applying pure moment loads in all modal directions of loading, thus enabling the *ex vivo* tests to occur in an environment that more closely resembles the native *in vivo* environment. Like any mechanical device, MASSUCE exhibits frictional hysteresis, however by using external cameras to record segmental motion and placing the torque sensors as close to the segment as possible, these effects were minimized. The drawing packages for the hardware as well as documentation of the control program are provided in Appendix A.

As the tests performed for this work were conducted under physiologic conditions (including a compressive follower-load at body temperature and continuous-speed loading), the cadaveric segmental response more closely matches the *in vivo* response. The results advance current knowledge about the effects of various testing conditions on spinal biomechanics, which can be used to validate other mathematical and engineering models of the lumbar spine (e.g., finite element models) as well as form the basis of design parameters for orthopaedic implants for the lumbar spine. Specimen preparation follower published protocols, and the testing was performed using a statistical design of experiments, which can be found in Appendix B.

This thesis has presented the results from flexibility testing of 27 functional spinal units (FSUs), with analysis of testing conditions of a compressive follower-load, testing temperature, stepwise loading and various continuous-speed loading-rates within the range of voluntary motion. All the DIP-Boltzmann and calculated flexibility parameters for the torque-rotation data collected in this study are included in Appendix C.

7.2. Recommendations for Future Work

This work quantifies the variation in the lumbar spine flexibility with regards to testing temperature, loading-rate, and a compressive follower-load, and confirms that current spine biomechanics testing methodology may be improved by testing at body temperature with a compressive follower-load and at a common loading-rate. While this research was performed solely to investigate the rate-dependent viscoelasticity of the lumbar FSU at body temperature and room temperature, the results have application to both numerical modeling and medical device design. Viscoelastic effects have usually been ignored in these fields, presumably due to lack of validation data. The present work demonstrates that care should be given to extrapolating cadaveric testing results obtained at room temperature under quasi-static loading conditions to the *in vivo* situation.

Many studies have shown preconditioning of test specimen by performing three load/unload cycles and recording the response on the third cycle [22, 79]. Significant residual flexibility was observed to still be present in the test specimen following this example so the preconditioning procedure was extended to 20 cycles; after which, no more residual flexibility was apparent. This residual flexibility is due to the process that the test specimen was obtained (i.e., fresh frozen cadaveric specimen were obtained from a certified tissue bank). For example, if the specimen was frozen in a non-physiological or pathological position, then the healthy response may not be revealed within initial tests.

As the setup is expected to significantly alter the results, it is understood that in order to obtain the least amount of error between tests, the specimen or test setup should not be touched, moved, or altered in any way, and only the variable of interest should change (e.g., if the variable of interest is temperature, the purest data will be obtained by performing a single test at body temperature or room temperature, then immediately repeat the same test at the other temperature setting before performing any other experiment). The overall variability due to the test setup is expected to show diminished effects in the results with an increased sample size.

Finally, despite the magnitude of the work performed here, independent research is encouraged to confirm the findings presented in this thesis, taking into account the recommendations provided here.

7.2.1. Compressive Follower-load

Despite the increased amount of data obtained in the flexion-extension loading direction through the analysis of multiple continuous-speed loading-rates, the results obtained for flexion-extension loading were determined to possibly be skewed by the placement of the follower-load. Although care was taken to place the follower-load line of action through the axis of rotation of the functional spinal unit, the follower-load may have induced a moment and offset the torque that was observed when loading in flexion-extension. The results may also be weighted in flexion or extension as the axis of rotation translates when rotating in flexion-extension and lateral-bending. Furthermore, this source of error is magnified as flexion-extension is more sensitive to load placement (as discussed in Section 5.3.2). This potential source of error may be reduced by aligning the loading direction axis with the axis of the pulley wheel through which the follower-load is applied. The fidelity of the results for lateral-bending tests are not concerning as the axis of the pulley was consistently aligned with the lateral-bending loading direction axis.

Improved methodology is required for the application of a compressive follower-load in spine flexibility tests. Aligning the pulley axis with the loading direction is only one aspect to be addressed. Researchers have made progress in defining the path of the follower-load through each level of the lumbar spine [39, 64-68], but methods of improving the compressive follower-load are still available. For example, a constant 100-lb (440-N) weight was applied to each test specimen; however, every person is different in weight, height, muscle activation, and many other factors, such that a corresponding load specific for the individual would be more physiological. Furthermore, the follower-load was applied through an iterative process such that the change in torque between the loaded and unloaded test setup was constrained; however, since this is done within the neutral zone, where large degrees of rotation are experienced with small increments in torque, it is also recommended to constrain the change in position (i.e., rotation).

7.2.2. Body Temperature Testing

The best method for temperature analysis would require no changes in experimental setup between tests at room temperature and tests at body temperature. This, however, would require multiple heat/cool cycles if testing also occurred in different loading directions, rates, etc. Due to the lack of available test specimen, it is not recommended to cycle the temperatures; however, researchers should test at body temperature in order to not ignorantly omit necessary design parameters.

7.2.3. Dynamic Loading Testing

This predictive model does not allow for cross-temperature estimations. More work is required for determining this relationship. However, the predictive model allows for straightforward estimation of spinal segment torque-rotation behavior at rates spanning the range of voluntary motion based on determination of the response at a single rate at either room temperature or body temperature.

Many studies were found where spine motion was achieved by applying the load as a torque-rate, which is the time-derivative of torque (i.e. loading-rate $\doteq N \cdot m/_{sec}$). The author strongly encourages researchers to apply loads according to the hybrid model described by Panjabi [93, 94], such that the spine tester utilizes torque-control for end-range limits (e.g. $-7.5\ N \cdot m\ \leq T \leq 7.5\ N \cdot m$, and position-control in between limits where the motion is achieved by controlling the angular-rate, which is the time-derivative of angular position (i.e. loading-rate $\doteq {}^{deg}/_{sec}$). If a torque-rate was to be used while bending a spine segment through the neutral zone, where large amounts of rotation result from little torque input, the angular-rate would likely increase substantially to maintain the torque-rate through the neutral zone.

7.3. Implications for Orthopaedic Device Design

The mechanical response of a spine segment has typically been reported with regards to the range-of-motion (ROM) obtained in response to torque-rotation testing, and medical devices are designed within those constraints. Devices meet these specified requirements while not sufficiently matching the actual response of the segment. This leads to unnatural loading profiles, and eventual revision surgeries to replace, alter, or remove the orthopaedic device, which may have worked according to design specifications; however, with hopes of producing a spinal implant that may feel and work as the healthy biological counterpart once did, more accurate design specifications are needed. This suggests more thorough testing of the biological specimen and an increased number of parameters to use for design specifications.

While this research was performed to investigate the temperature- and rate-dependent viscoelasticity of the lumbar FSU, more questions arise concerning the physical testing of medical devices. As multiple devices have been tested and proposed to conform to biological specifications of ROM, NZ, and K, tests were performed at various rates of loading, and there was not significant reason as to why the selected loading-rate was chosen. For this reason, a standard loading-rate (e.g., 4 deg/sec) would be beneficial for comparison of results and implementation in the design of devices, particularly when submitting new devices for evaluation by regulatory committees.

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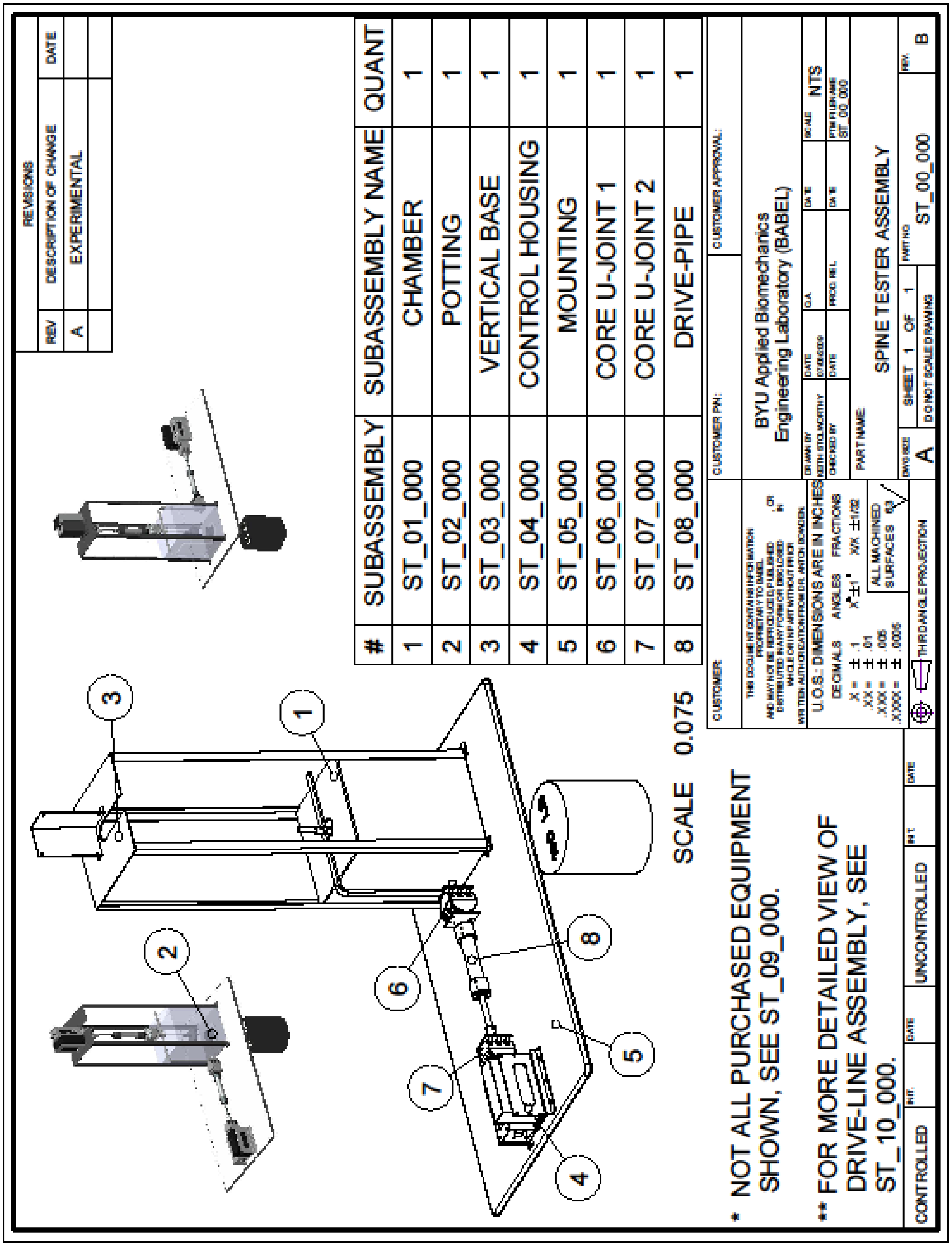
APPENDIX A. MASSUCE DESIGN AND DEVELOPMENT

A.1. MASSUCE Hardware

A.1.1. CAD Assembly Drawing Package



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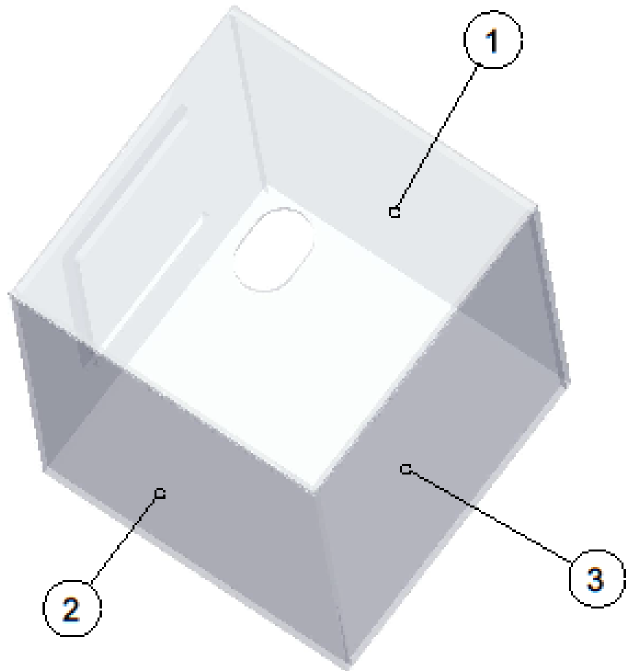

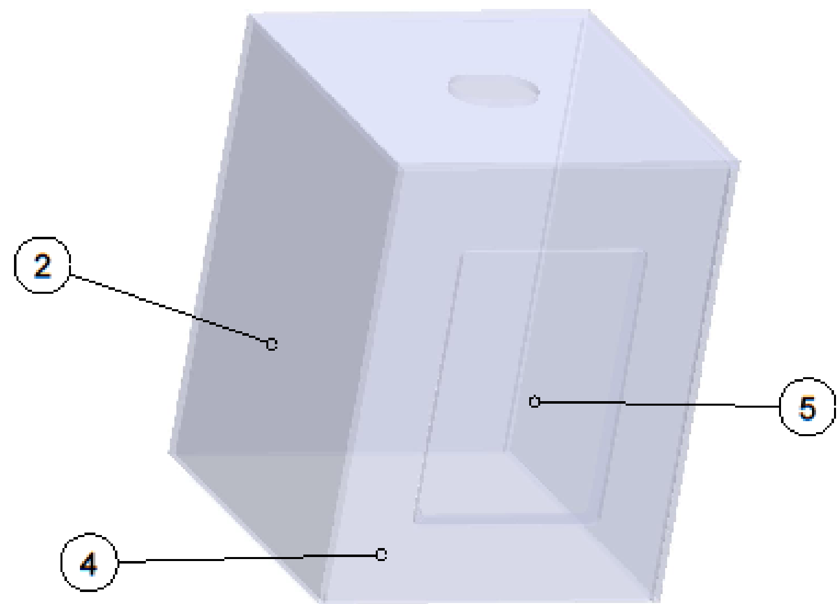

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CONTROLLED INIT. DATE UNCONTROLLED INIT. DATE

CUSTOMER: | CUSTOMER P/N: | CUSTOMER APPROVAL:

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BYU Applied Biomechanics
Engineering Laboratory (BABEL)

U.O.S.: DIMENSIONS ARE IN INCHES

DECIMALS: .X = ± .1; .XX = ± .01; .XXX = ± .005; .XXXX = ± .0005
ANGLES: X° ±1°
FRACTIONS: X/X ±1/32
ALL MACHINED SURFACES 63

THIRD ANGLE PROJECTION

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CHECKED BY | DATE | PROD. REL. | DATE | PTM FILENAME: ST_01_000

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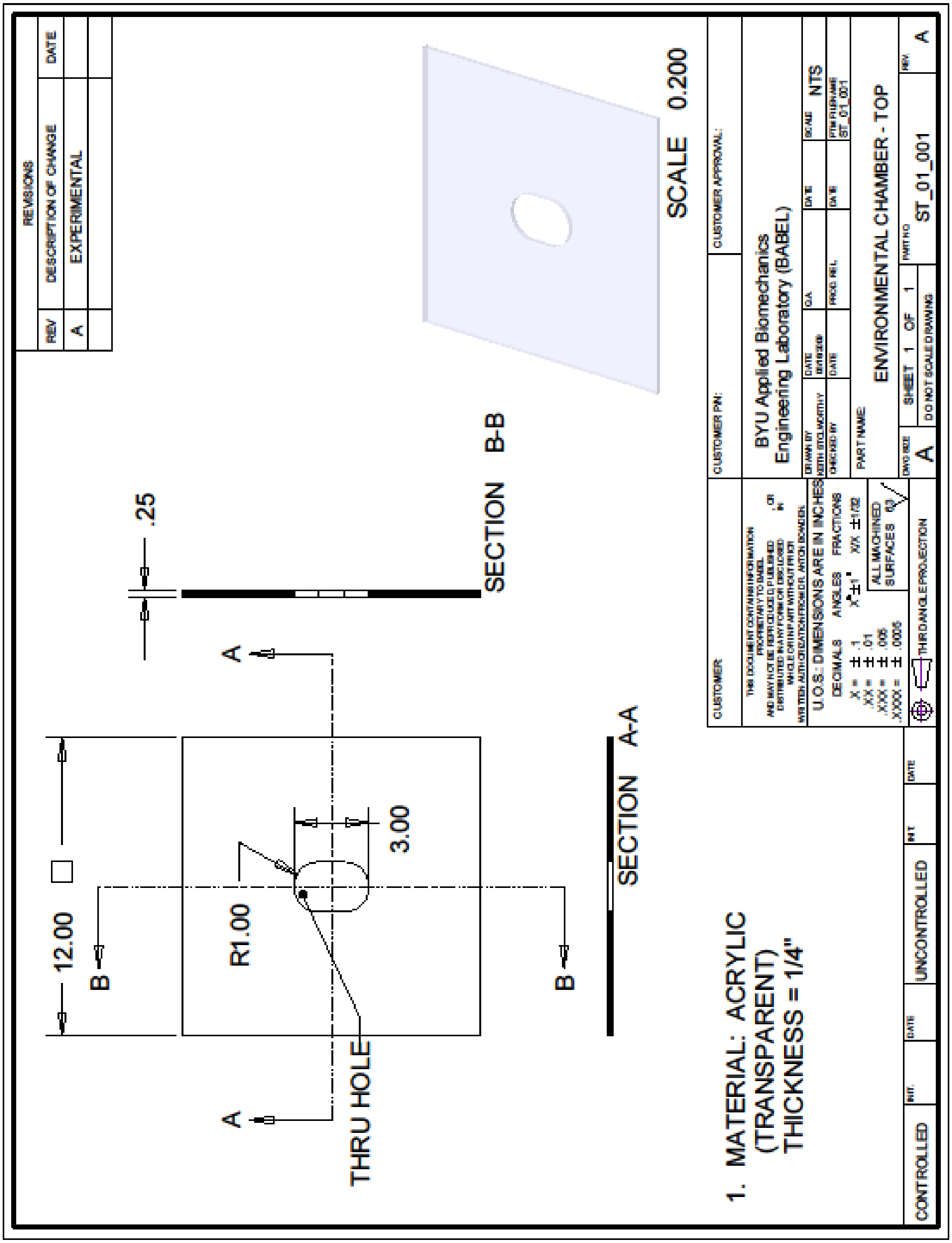
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CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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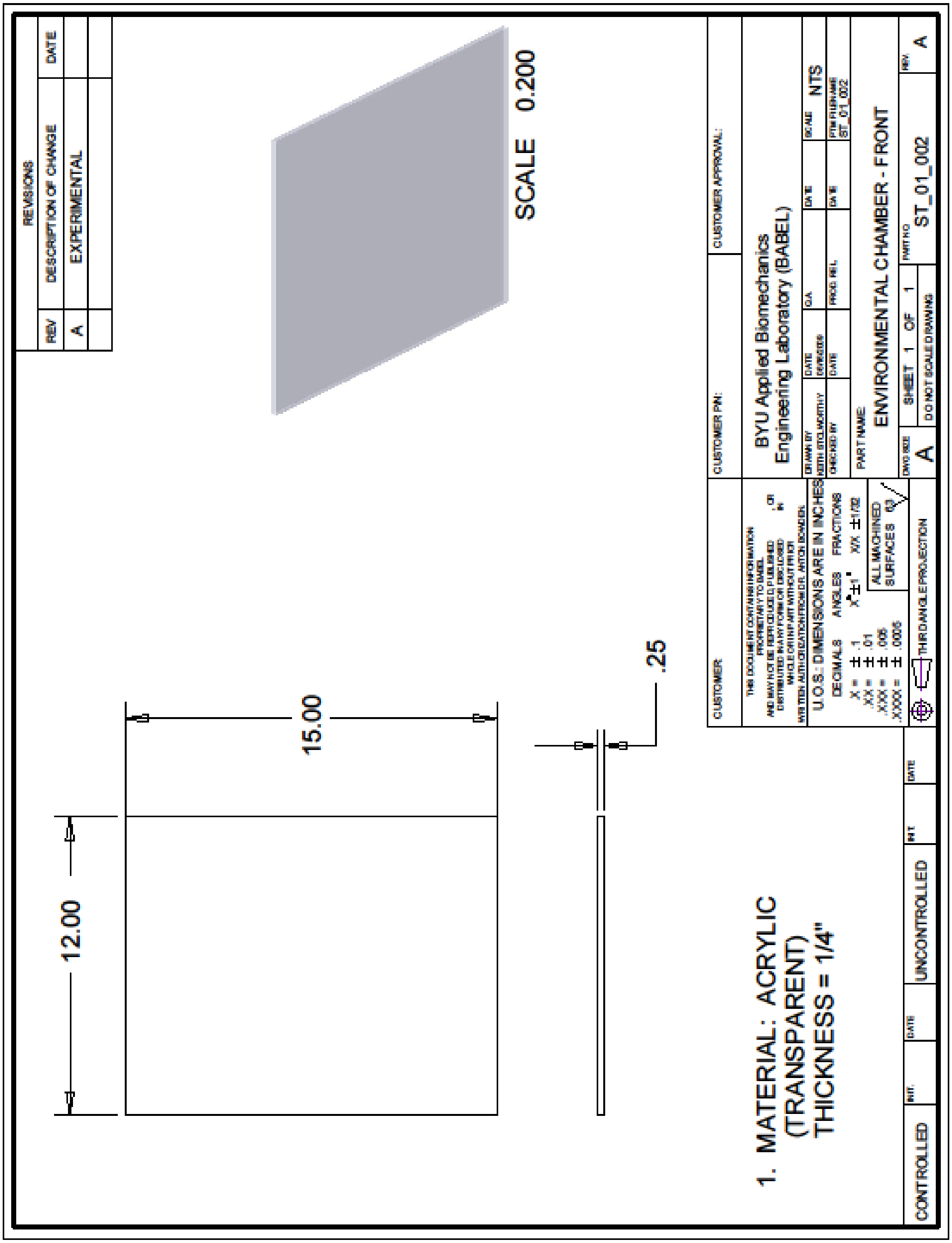
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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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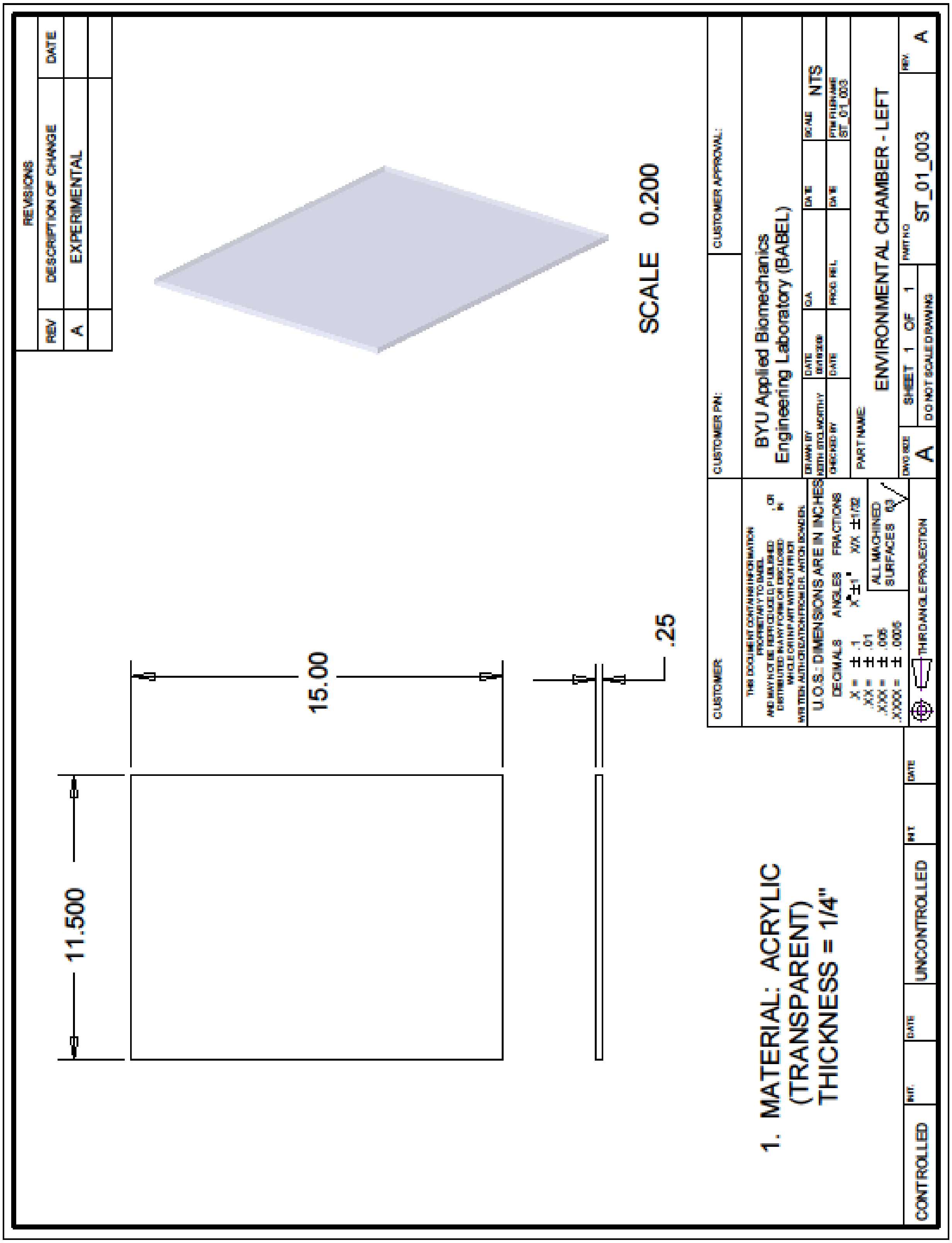
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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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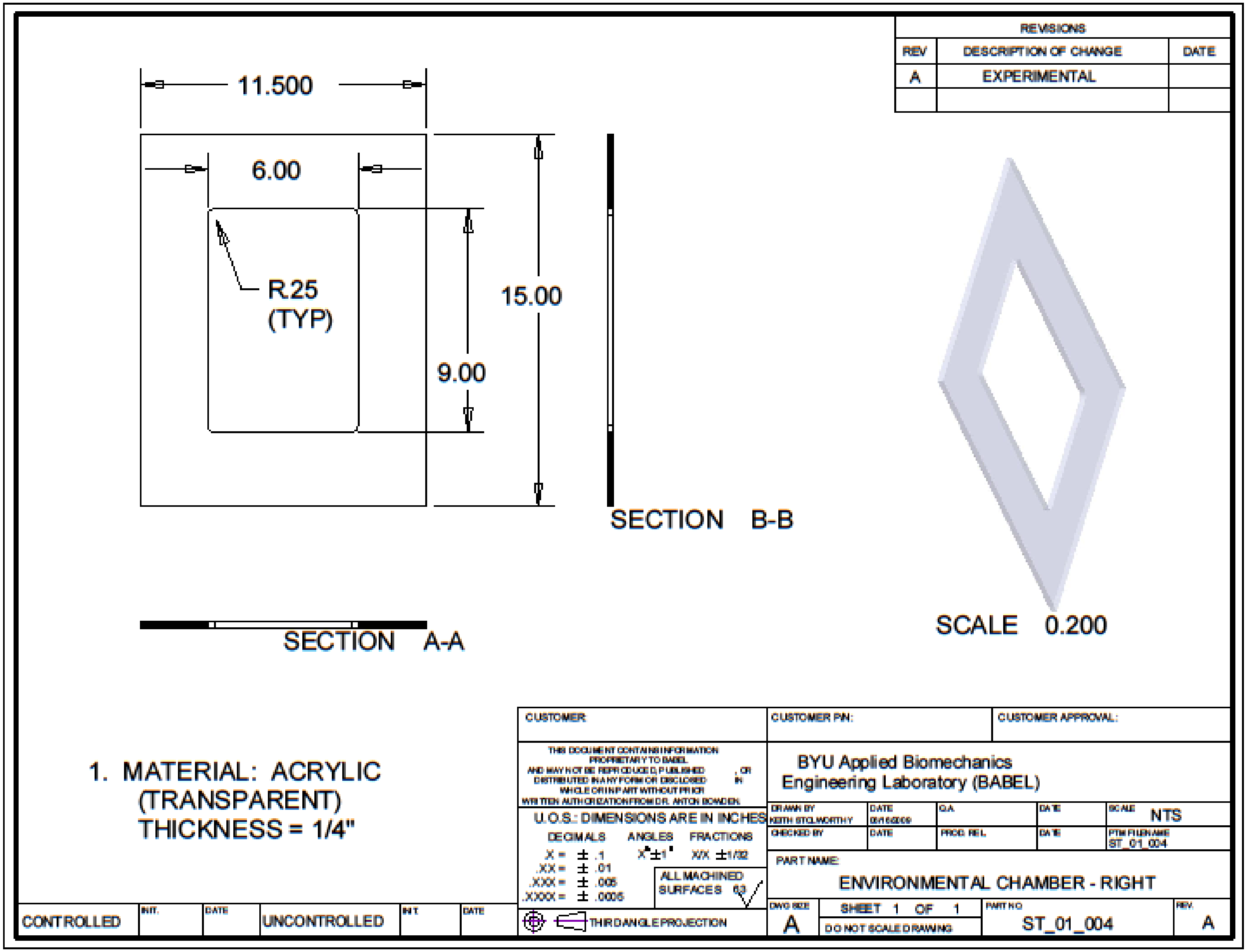
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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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KEITH STOLWORTHY
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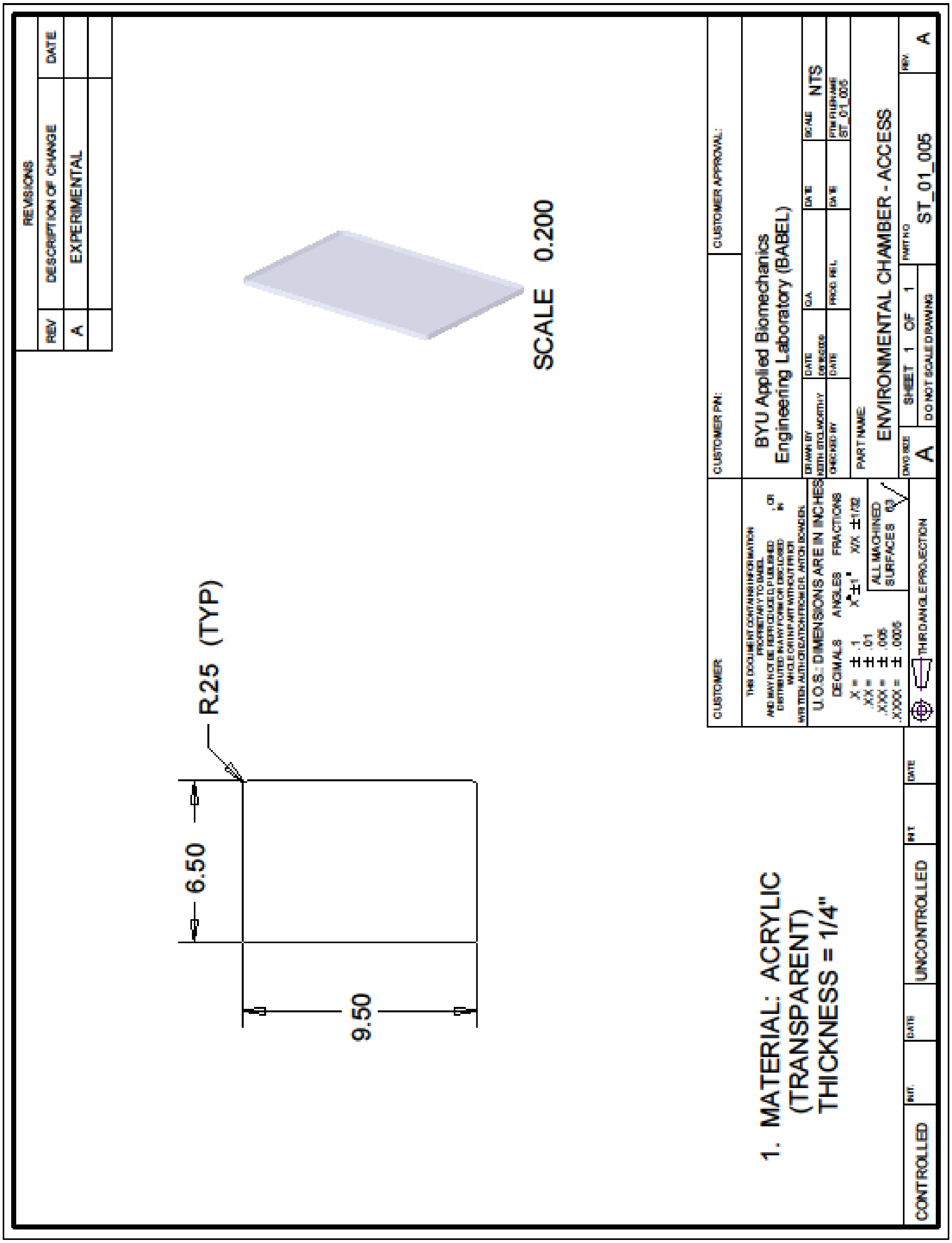

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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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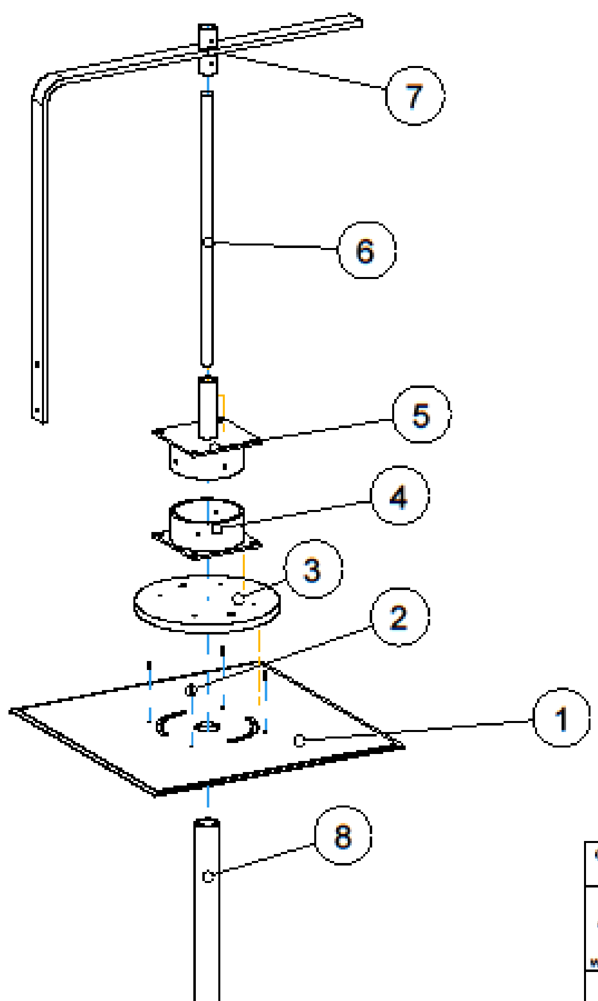

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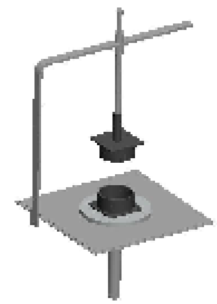

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ALL MACHINED SURFACES 63

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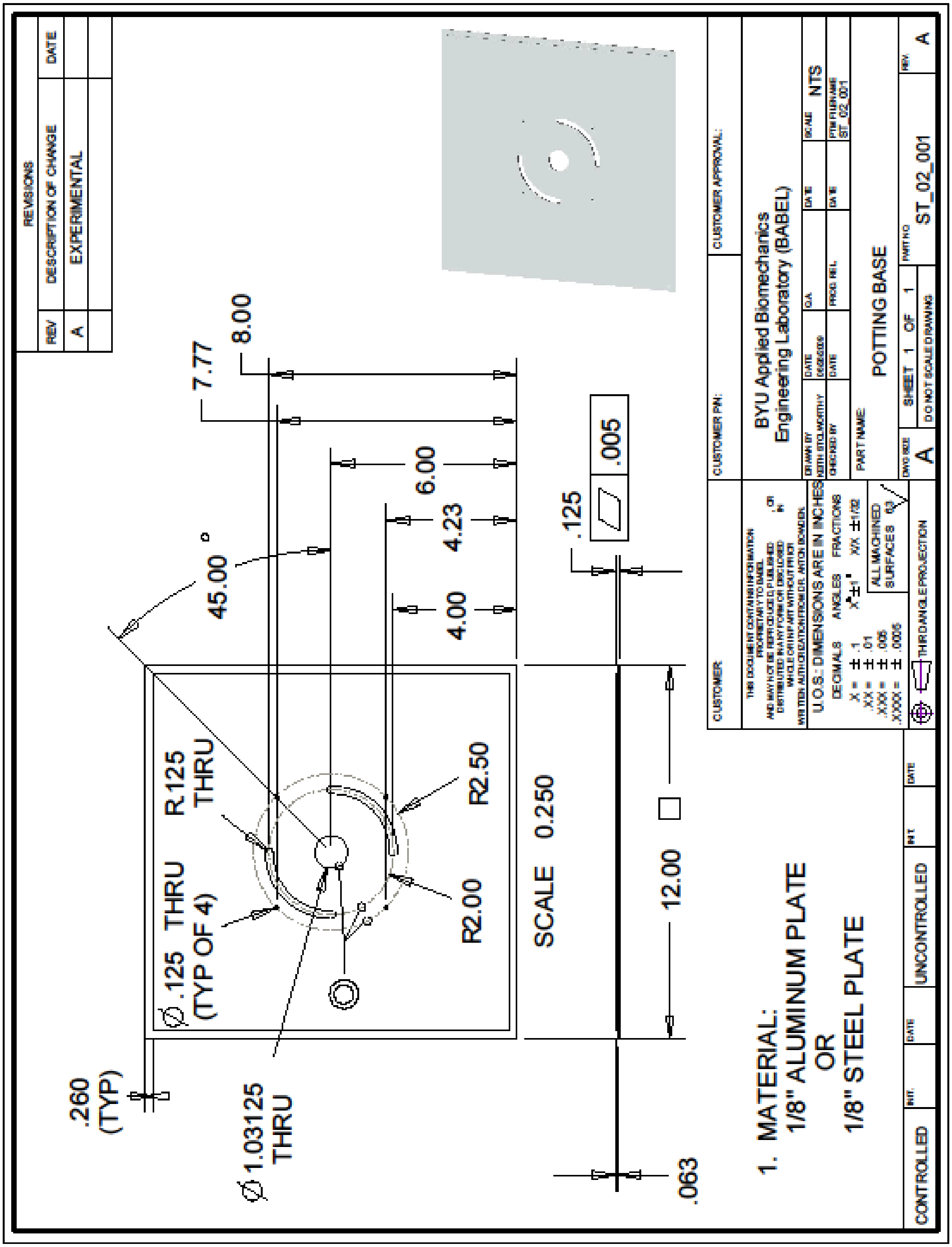
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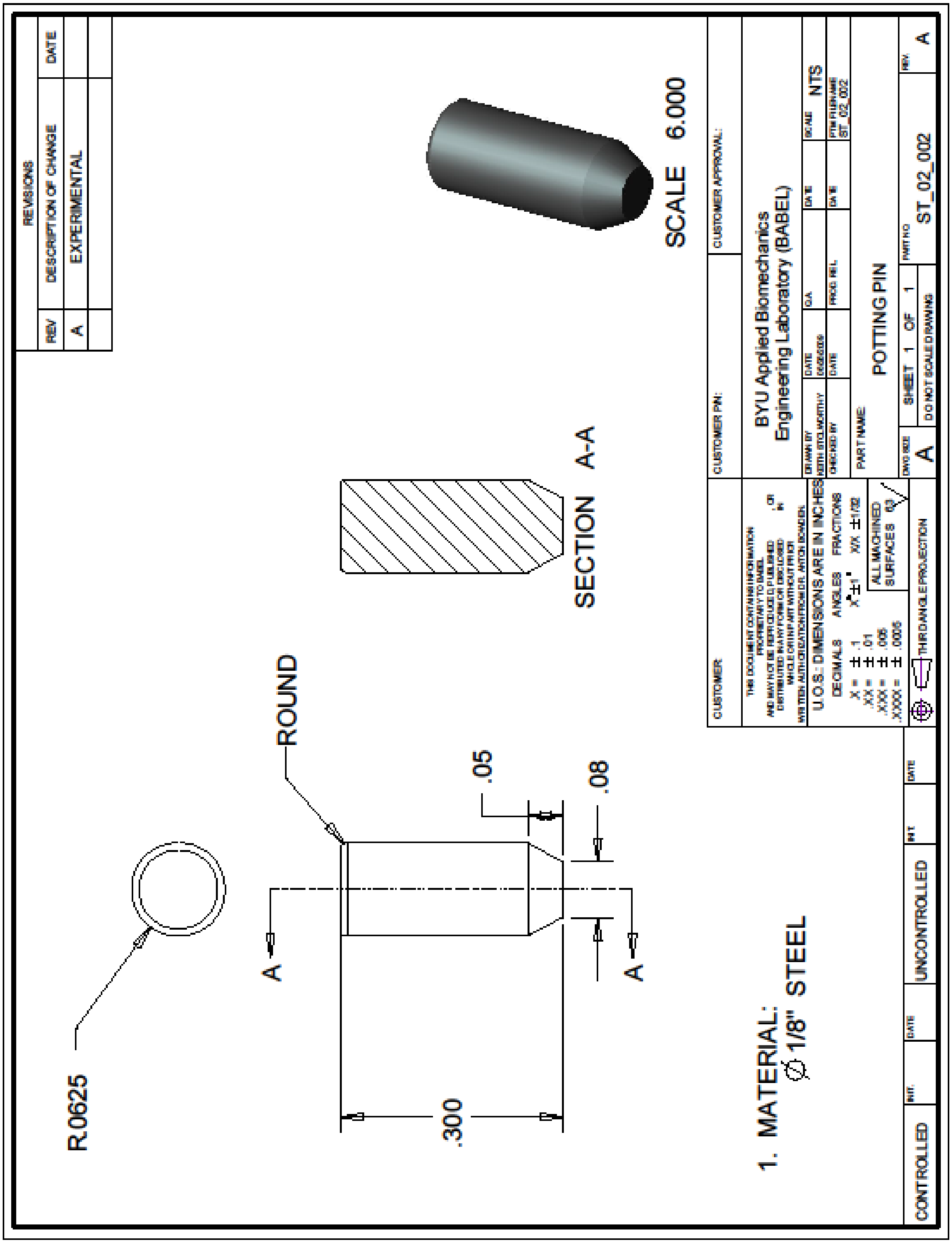
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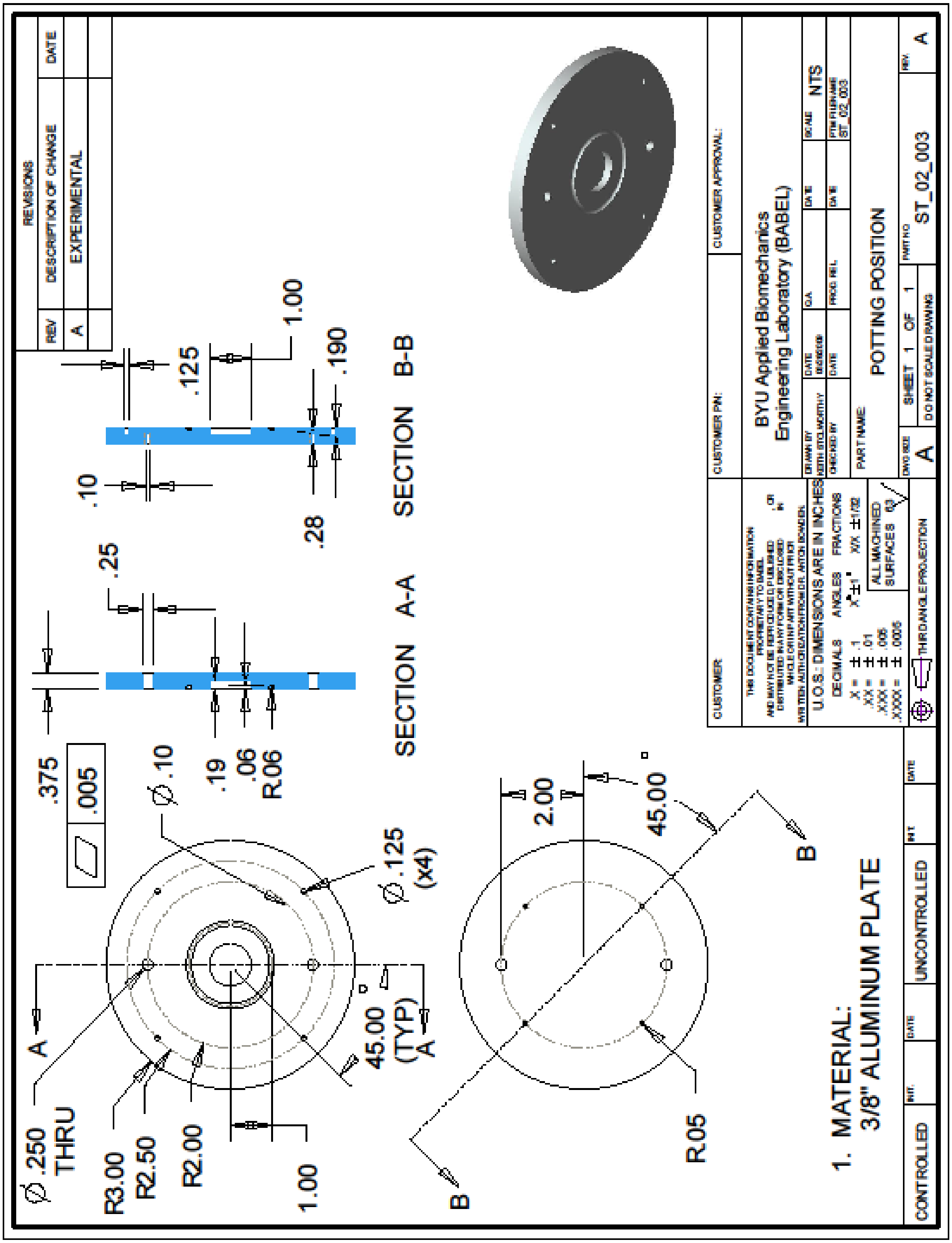

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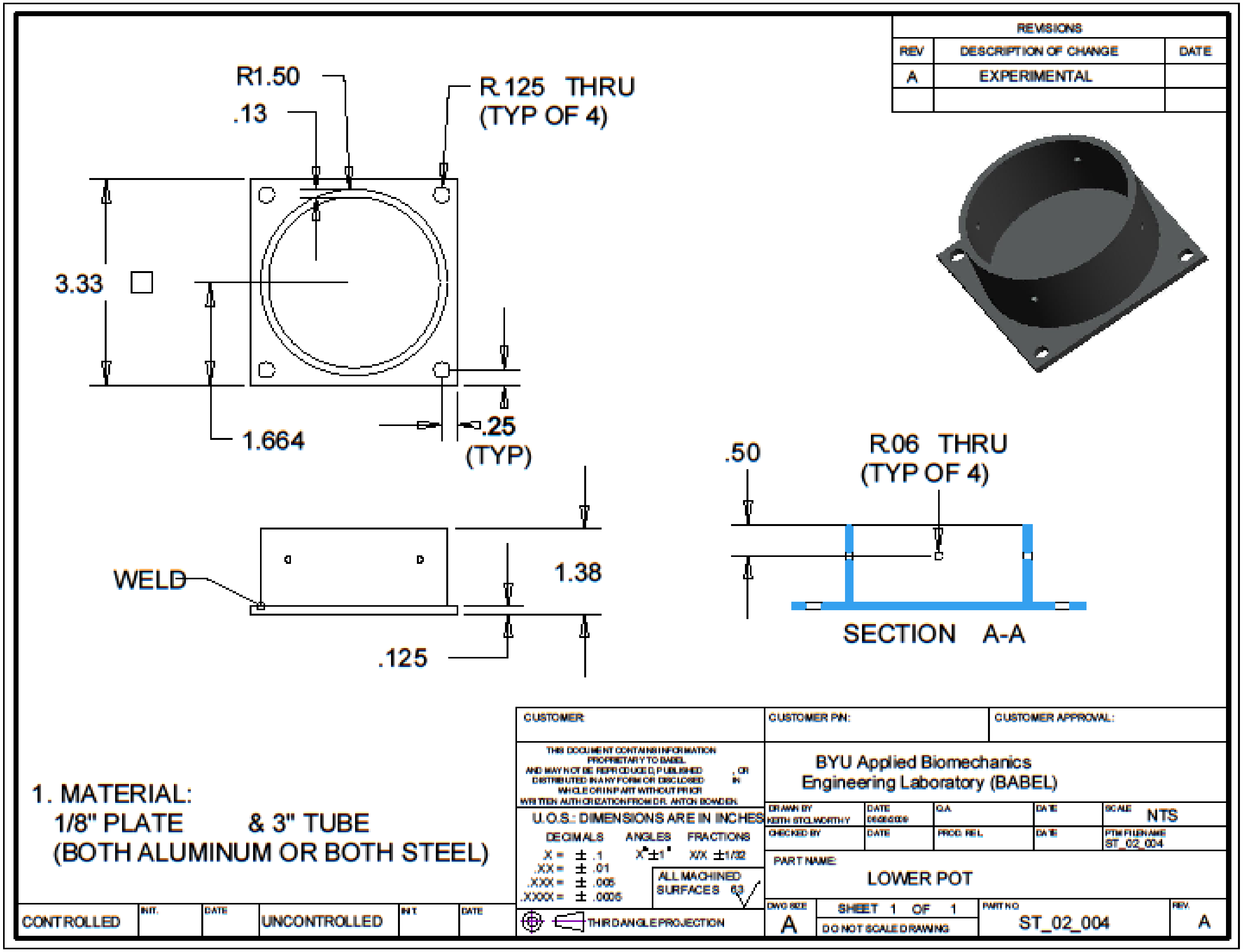
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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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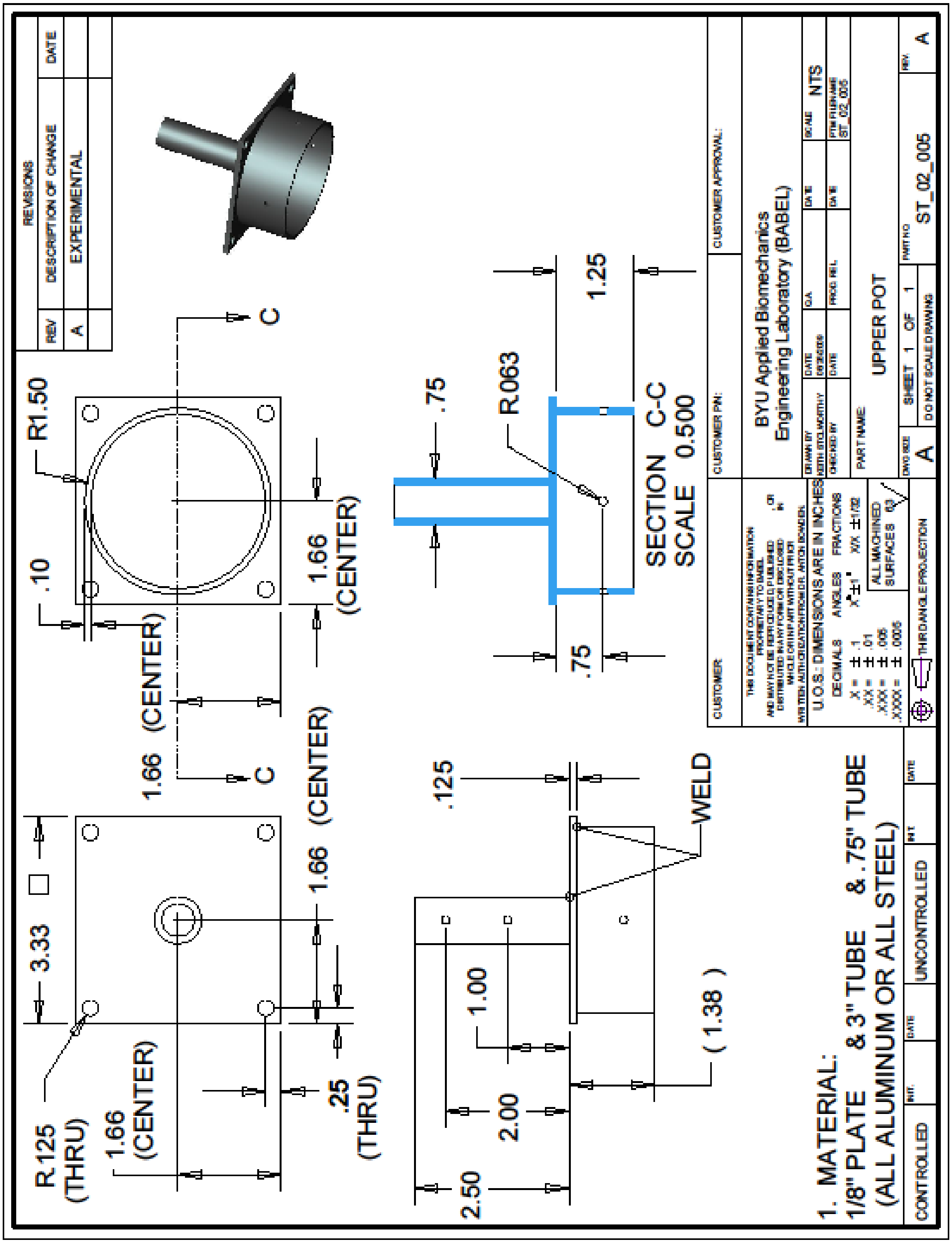
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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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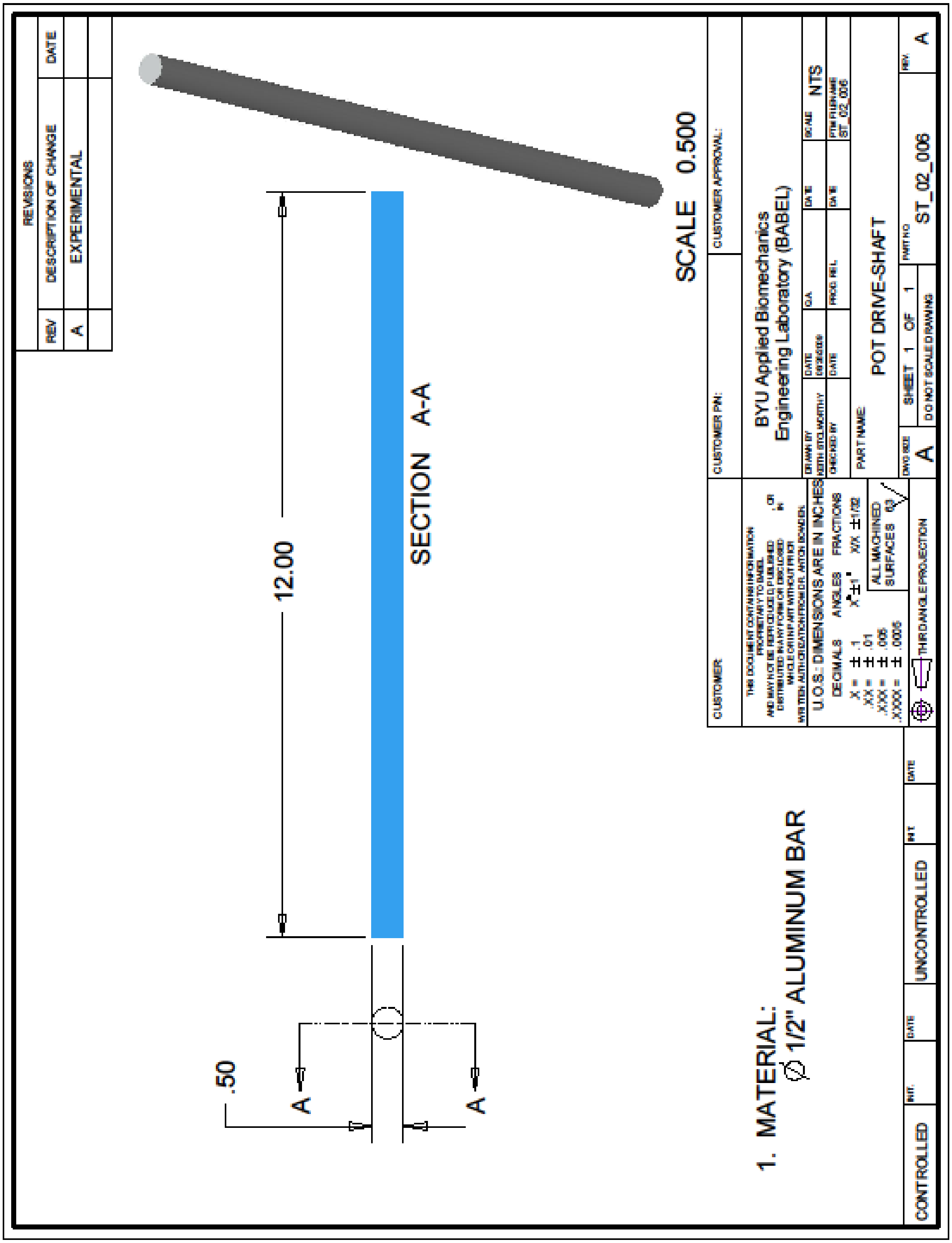
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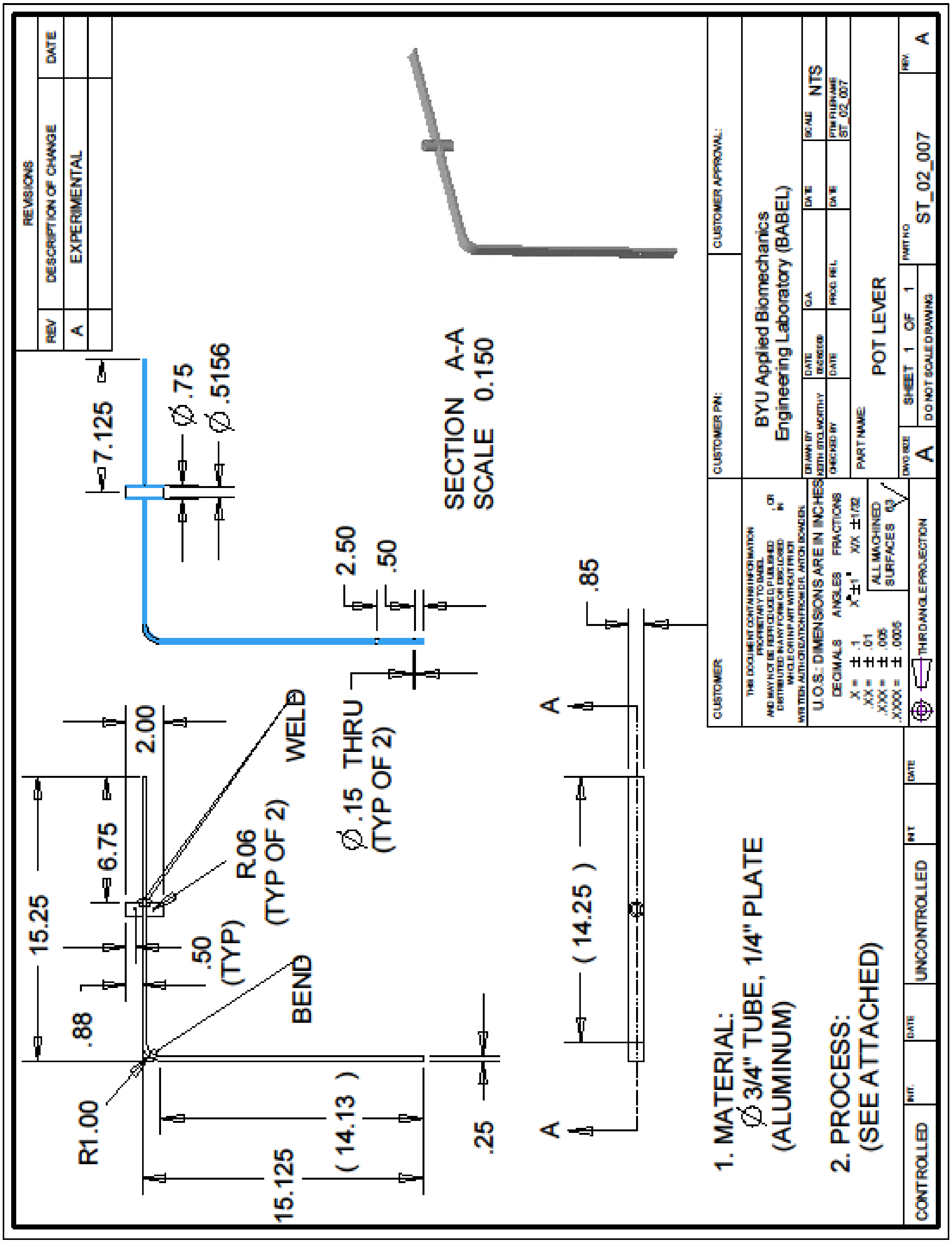

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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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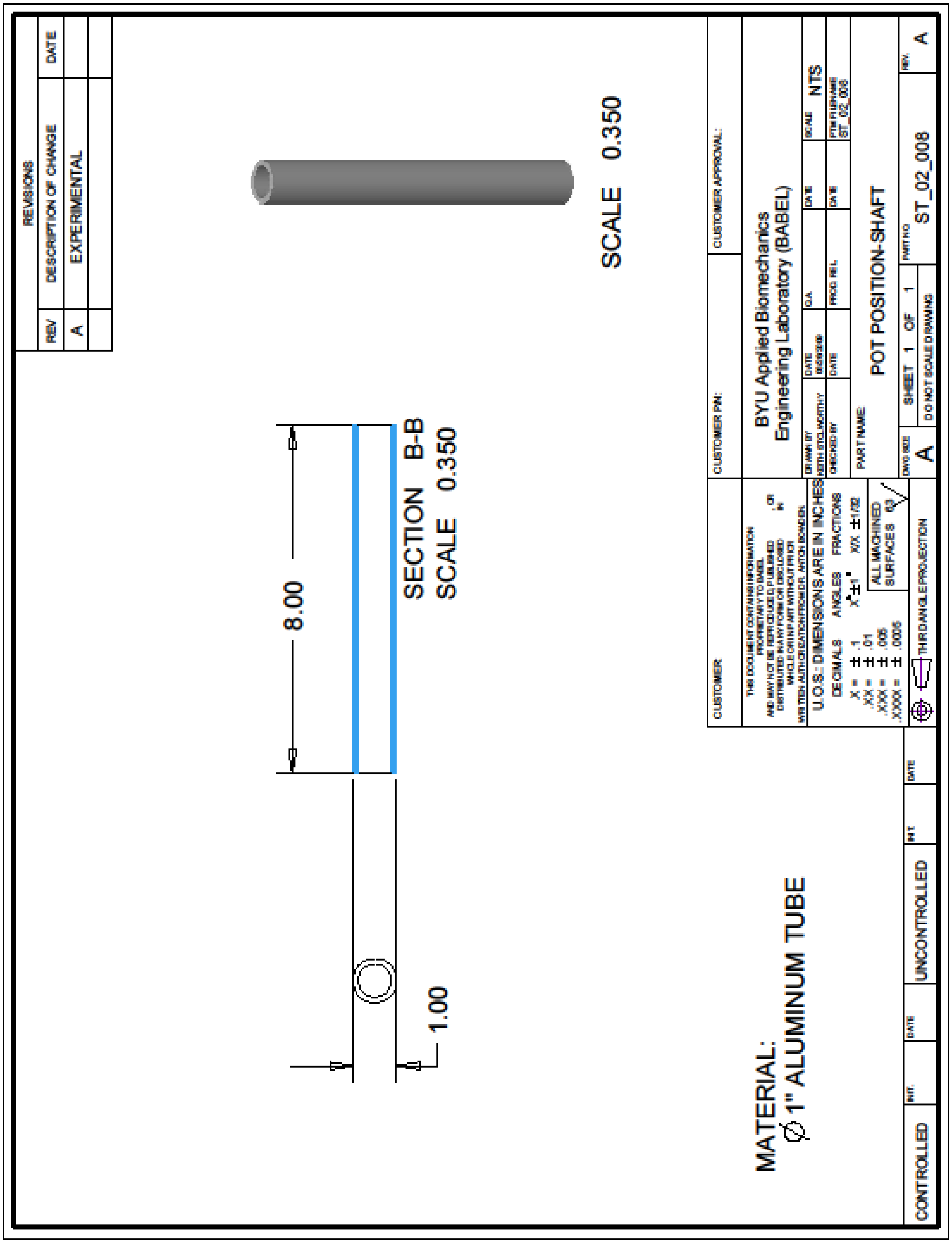
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BYU Applied Biomechanics
Engineering Laboratory (BABEL)
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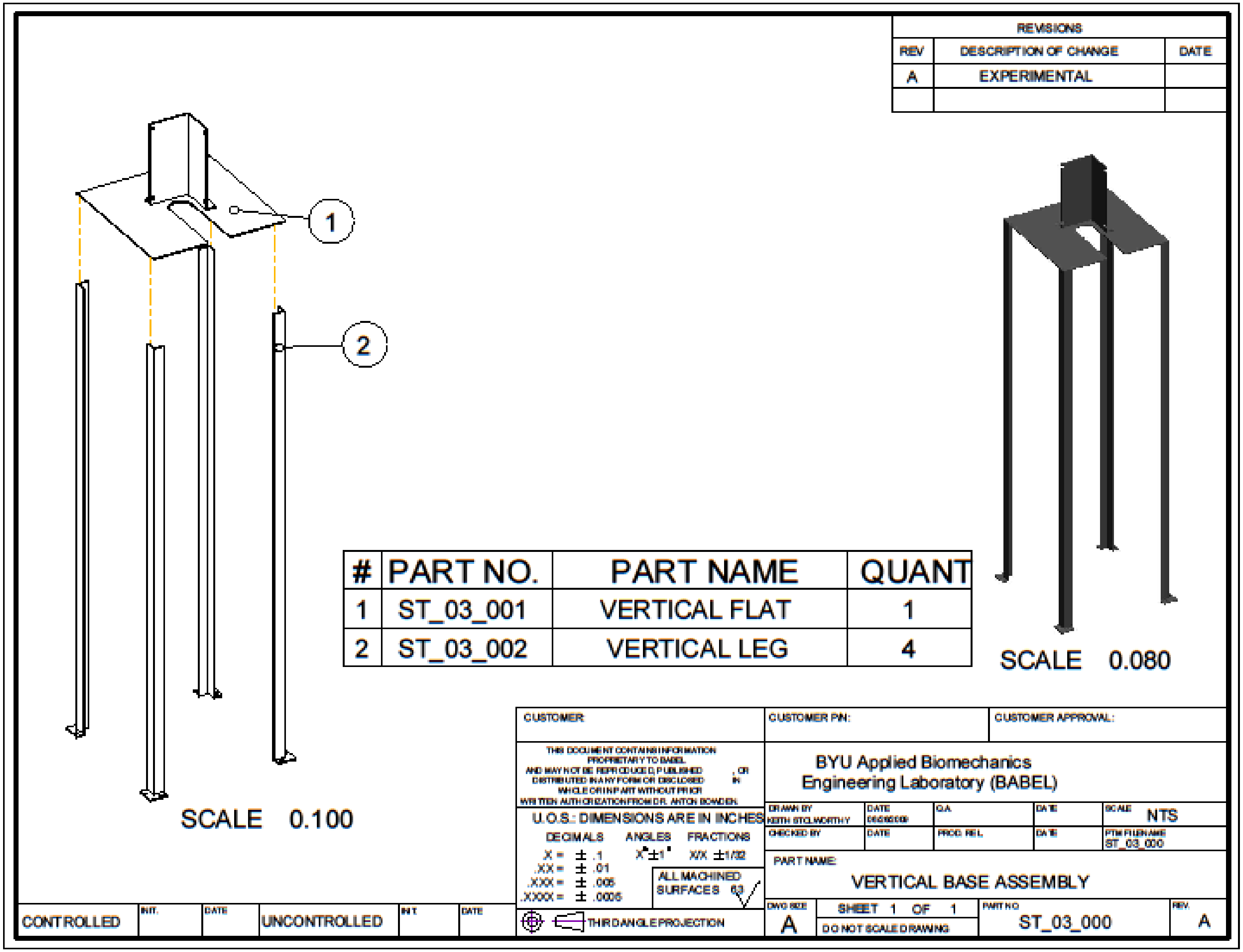
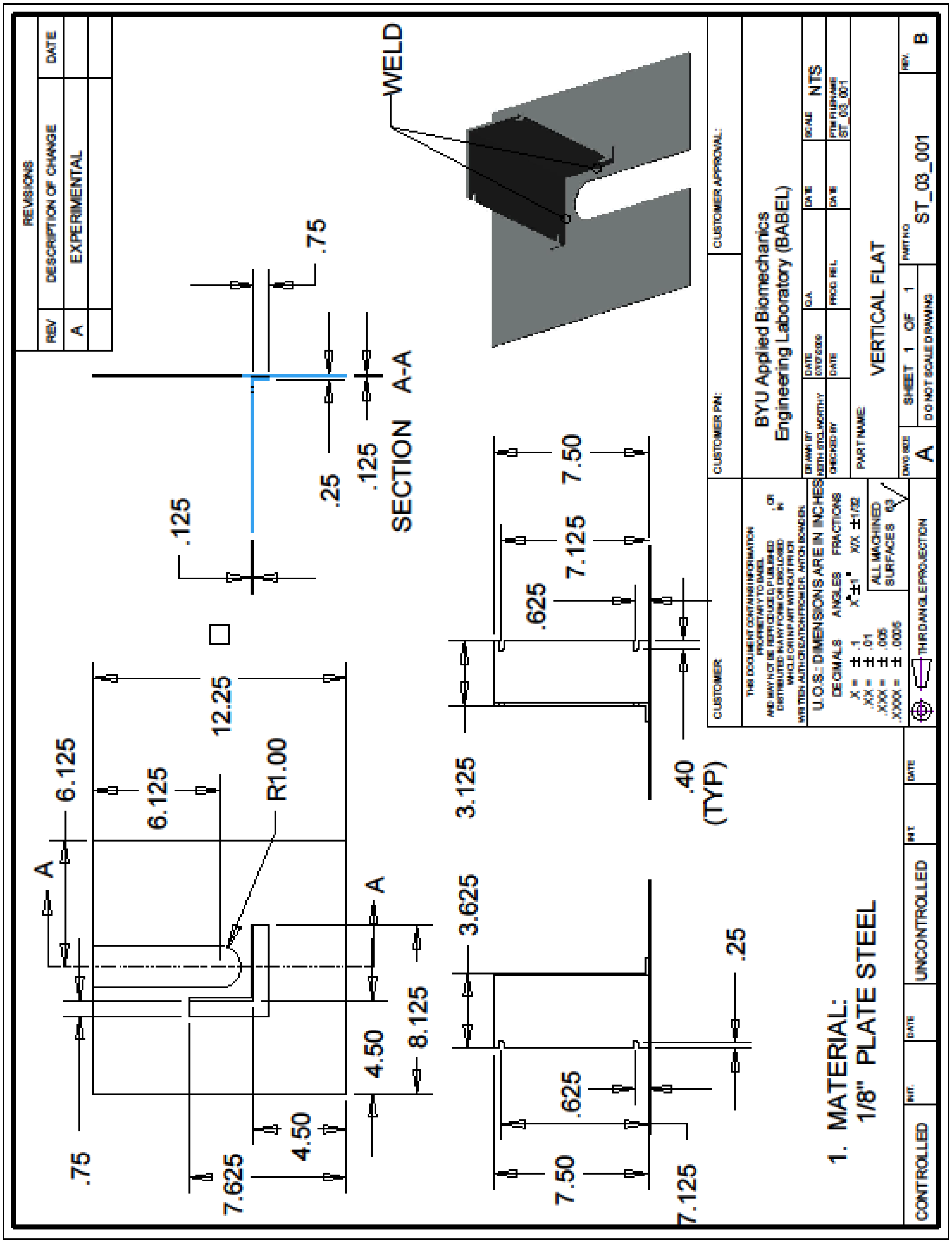
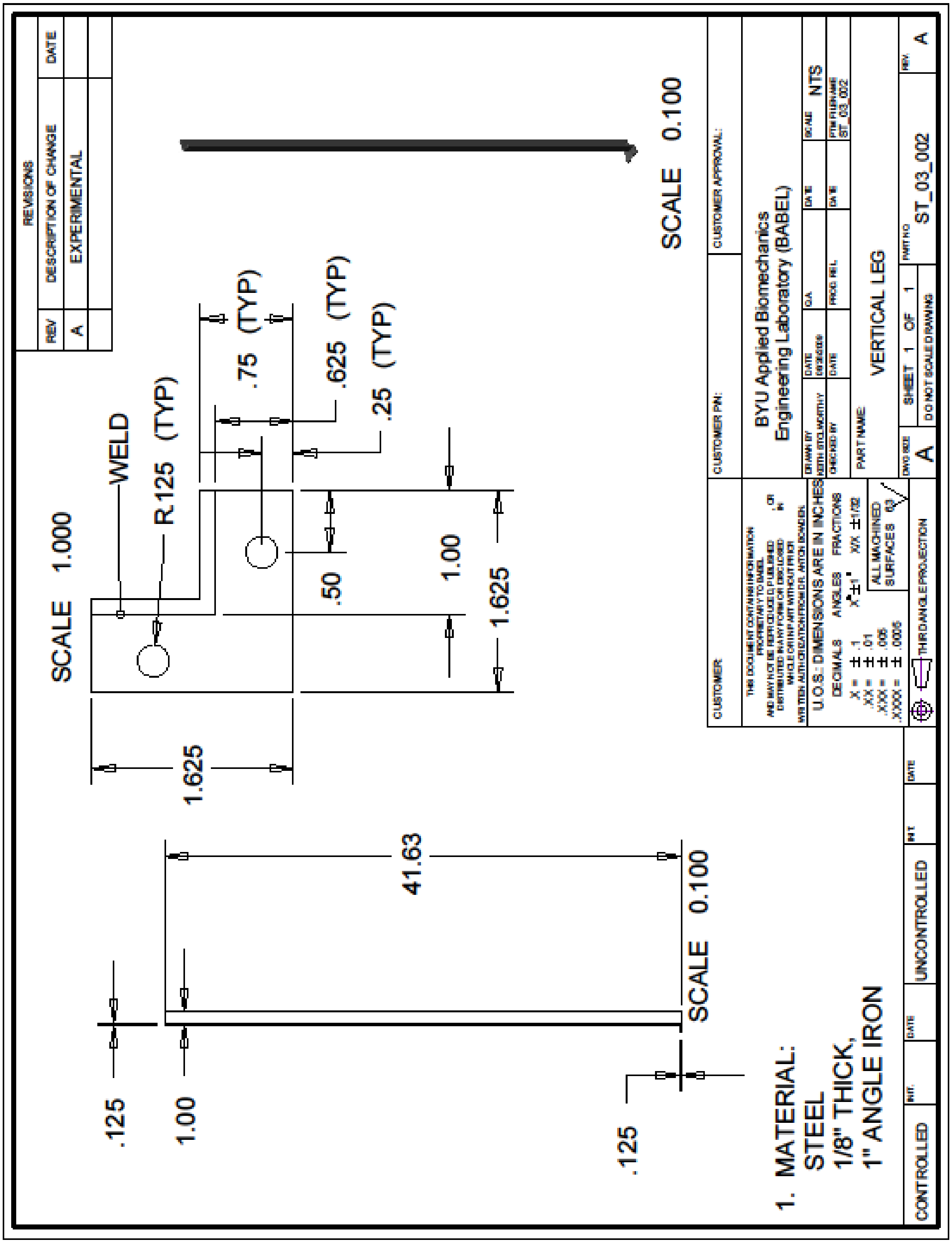
CONTROLLED
UNCONTROLLED

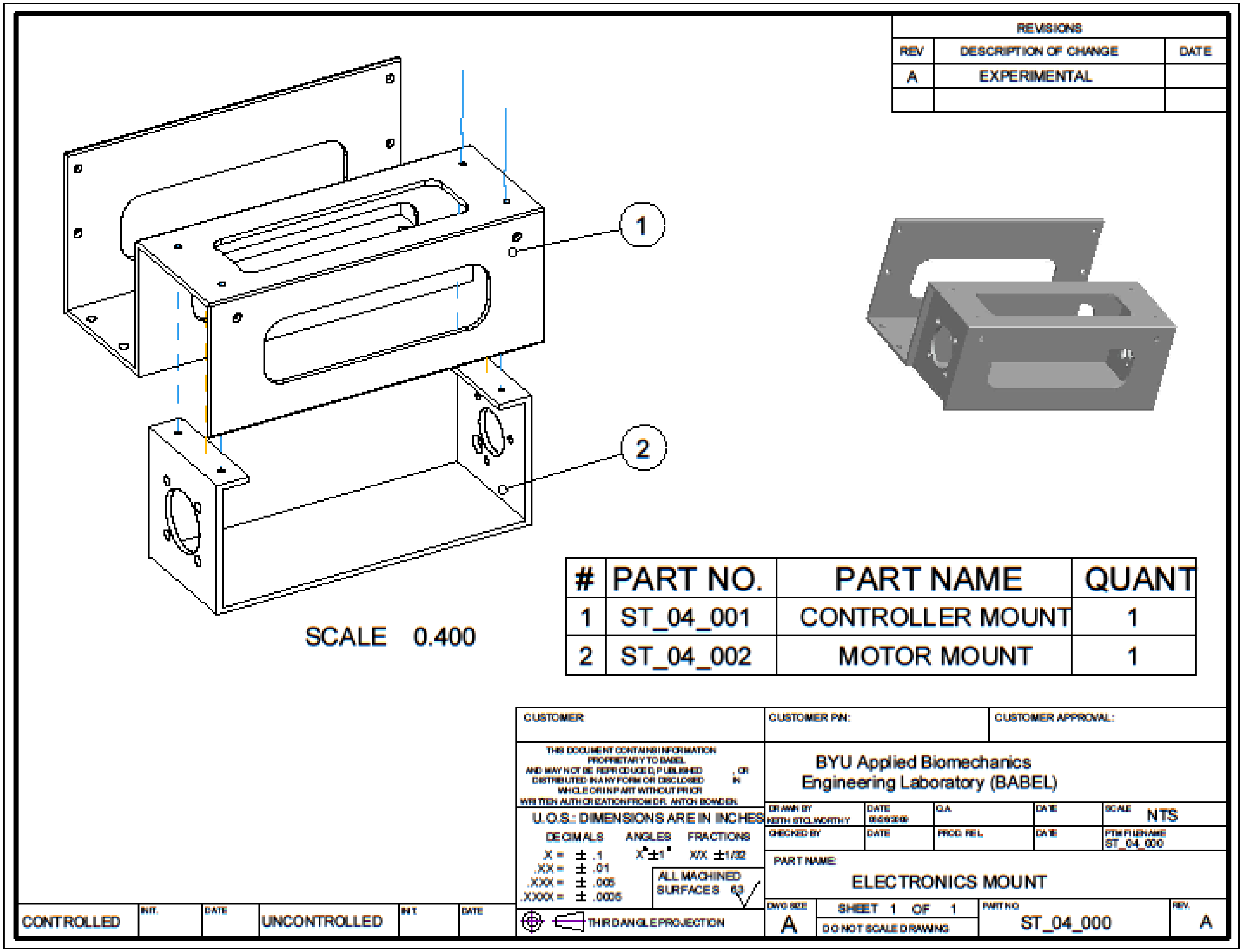


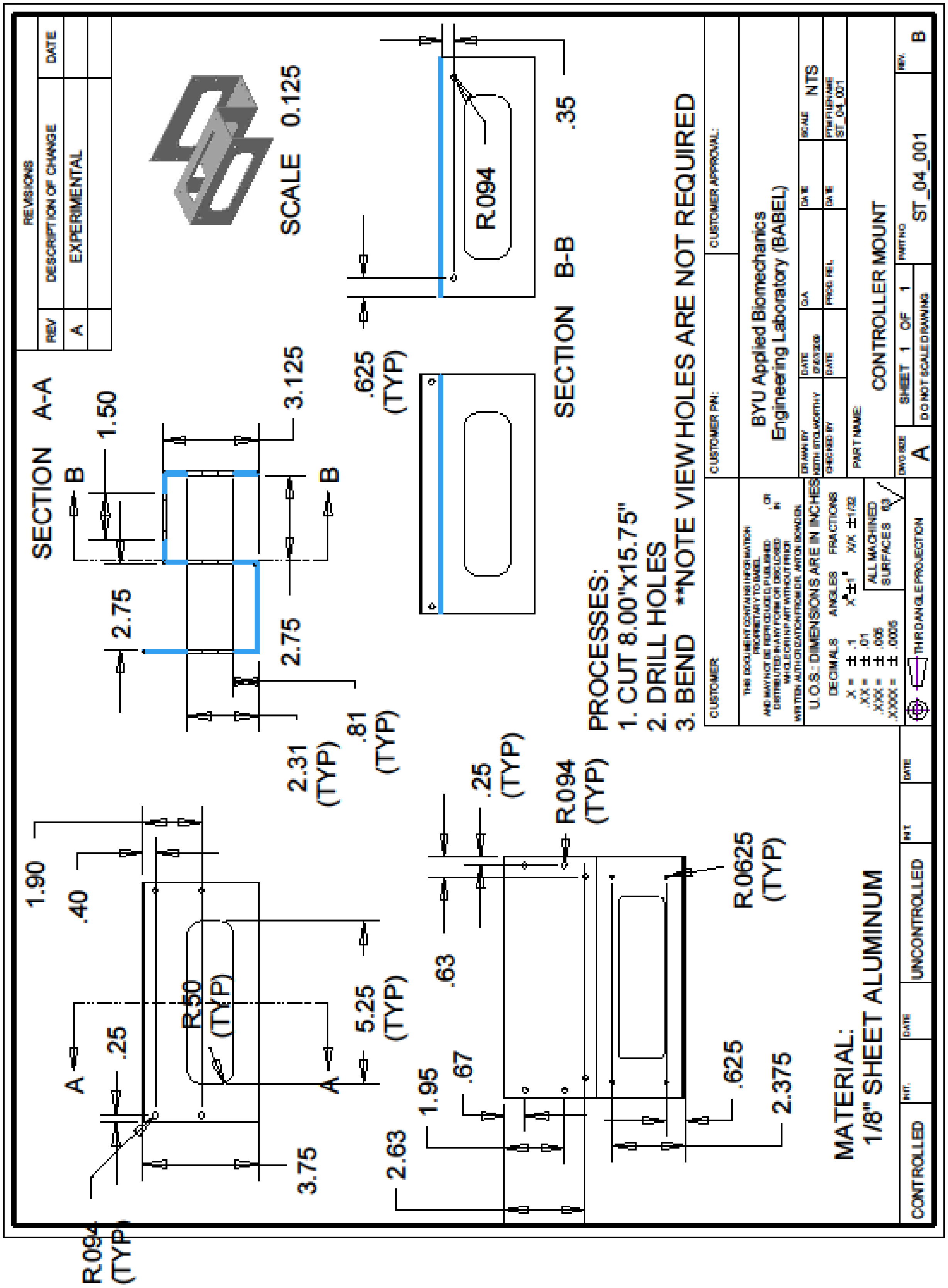
#	PART NO.	PART NAME	QUANT
1	ST_03_001	VERTICAL FLAT	1
2	ST_03_002	VERTICAL LEG	4

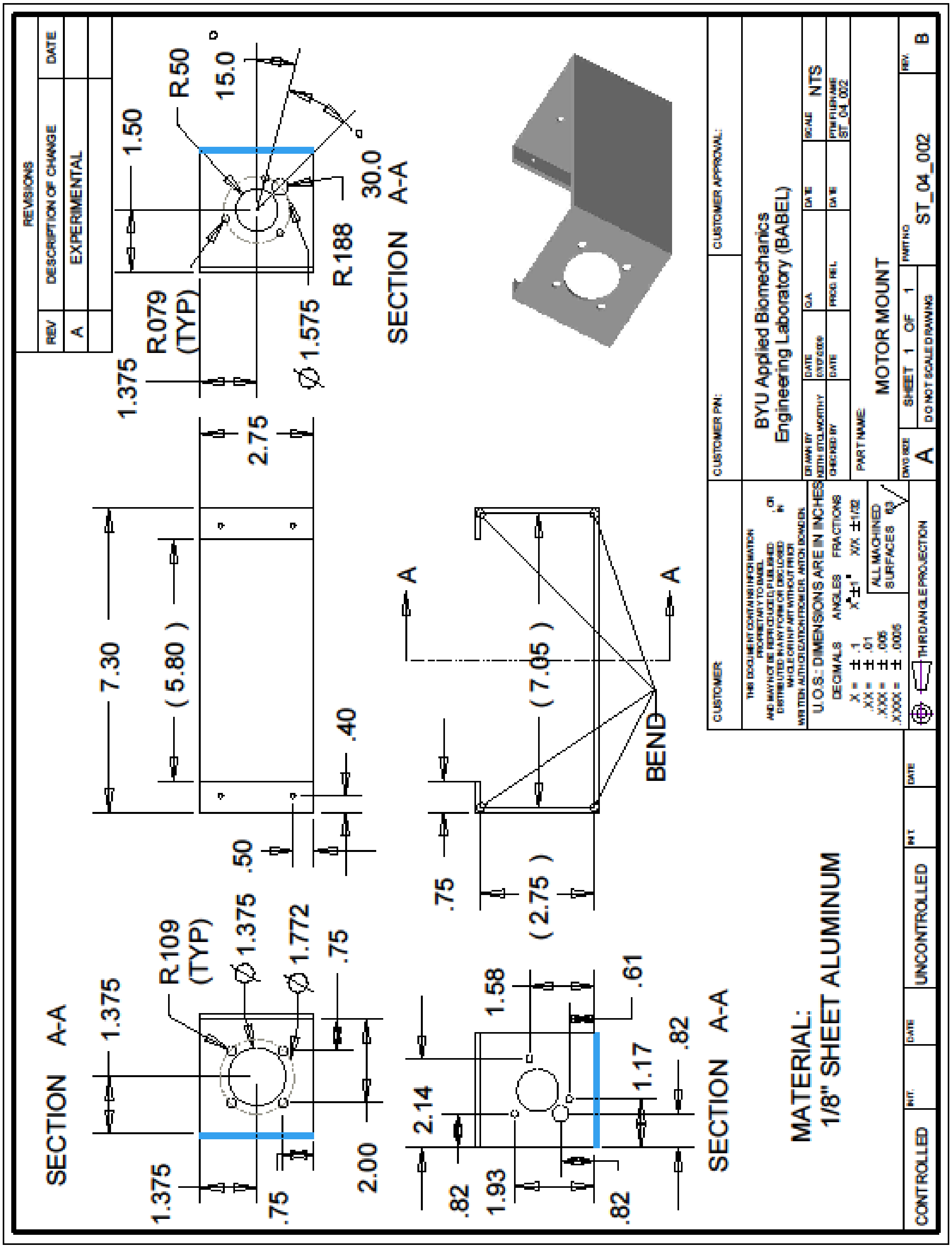

REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
WELD
SECTION A-A
.125
.25
.125
.75
12.25
6.125
6.125
R1.00
.75
7.625
4.50
4.50
8.125
3.625
3.125
.625
7.125
7.50
.625
7.125
7.50
.40
(TYP)
.25
1. MATERIAL:
1/8" PLATE STEEL
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
SCALE
NTS
PART NAME:
VERTICAL FLAT
SHEET 1 OF 1
DO NOT SCALE DRAWING
A
ST_03_001
B
THIRD ANGLE PROJECTION
CONTROLLED
UNCONTROLLED



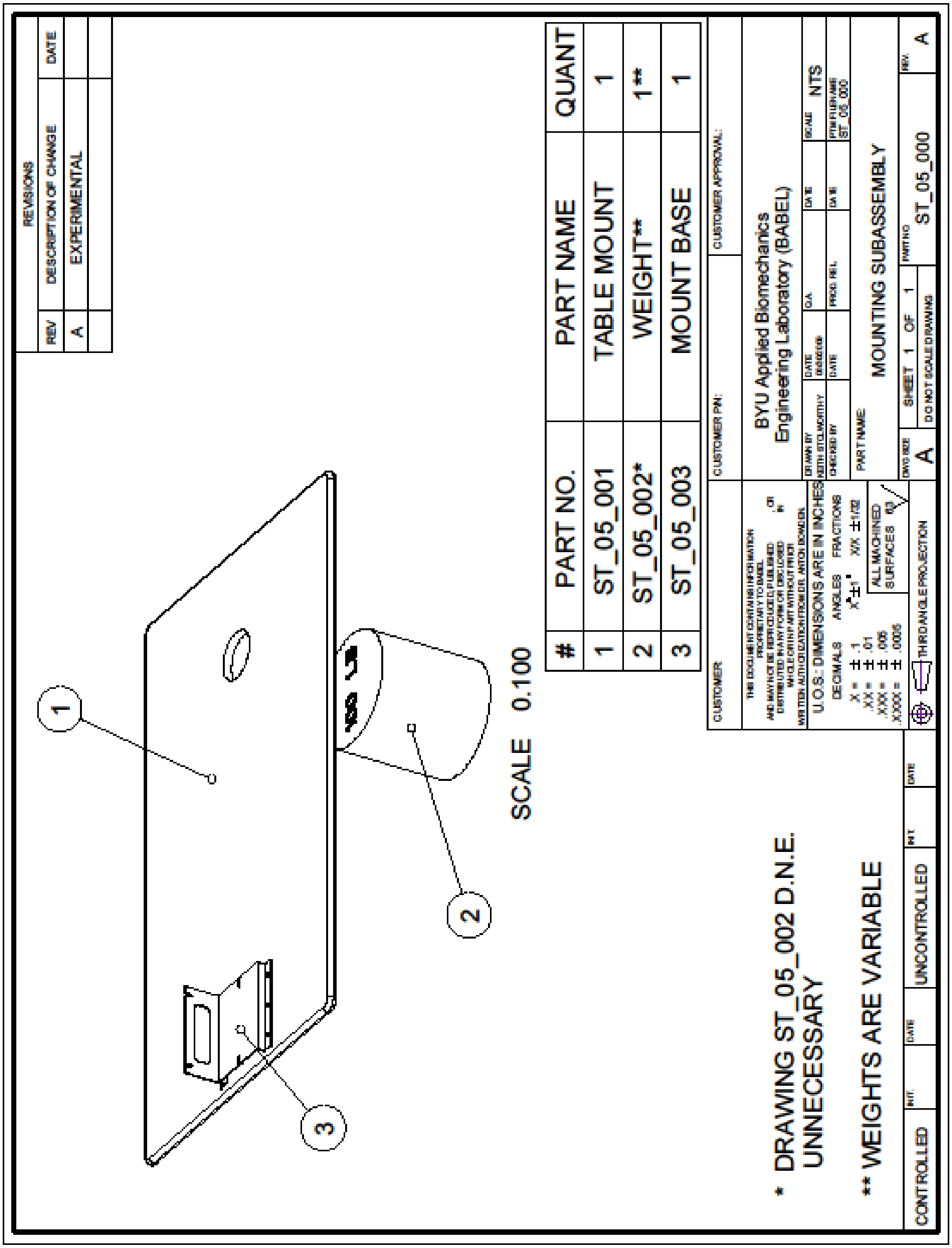
REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
SCALE 1.000
WELD
R.125 (TYP)
.75 (TYP)
.625 (TYP)
.25 (TYP)
.50
1.00
1.625
1.625
SCALE 0.100
41.63
SCALE 0.100
.125
1.00
.125
1. MATERIAL:
STEEL
1/8" THICK,
1" ANGLE IRON
CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
THIRD ANGLE PROJECTION
DRAWN BY
CHECKED BY
DATE
Q.A.
PROD. REL.
SCALE NTS
ST_03_002
PART NAME:
VERTICAL LEG
DWG SIZE
A
SHEET 1 OF 1
PART NO.
ST_03_002
REV.
A
DO NOT SCALE DRAWING
CONTROLLED
INIT.
DATE
UNCONTROLLED
INIT.
DATE

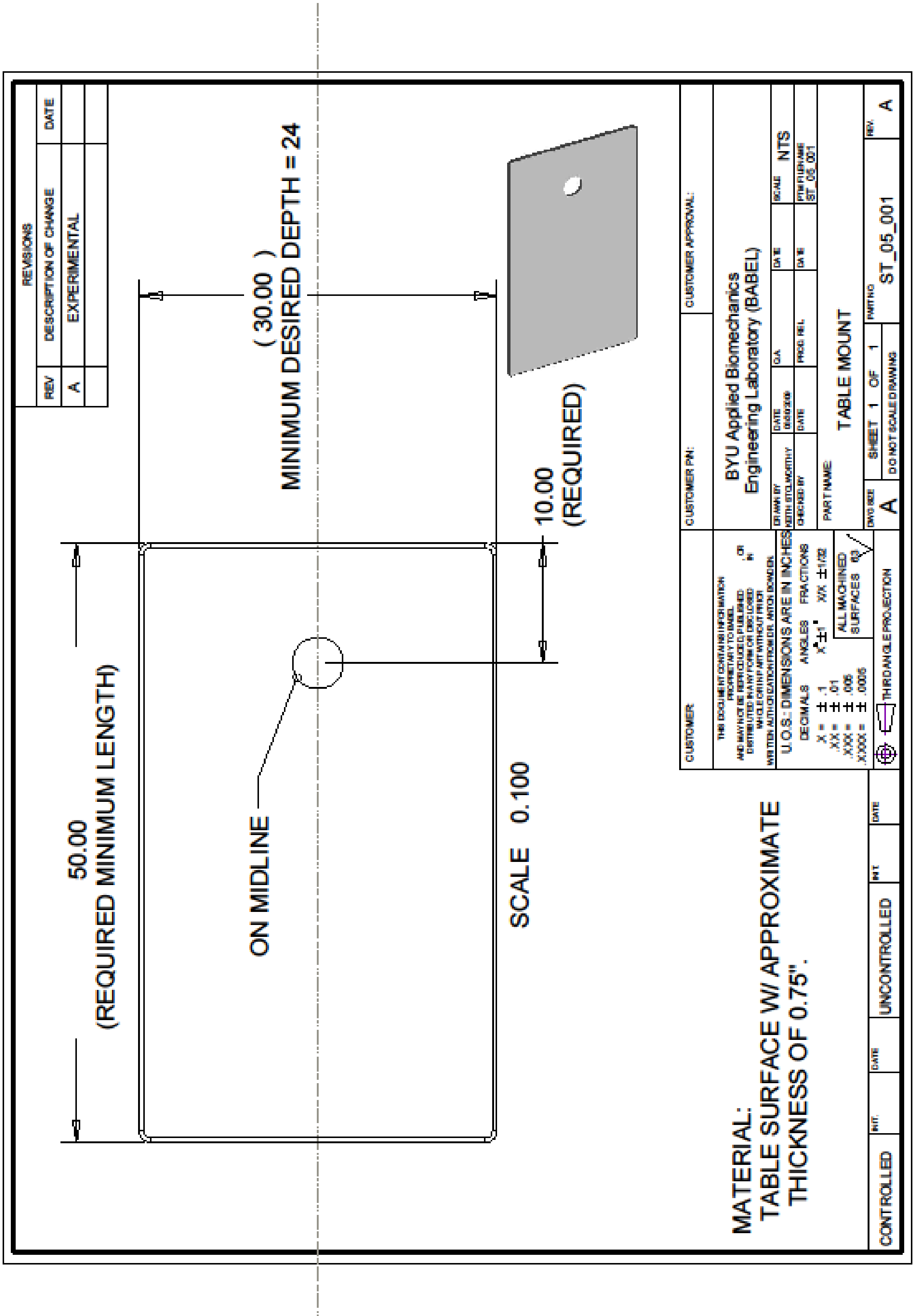

REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
1
2
SCALE 0.400
PART NO. PART NAME QUANT
1 ST_04_001 CONTROLLER MOUNT 1
2 ST_04_002 MOTOR MOUNT 1
CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
.X = ± .1
.XX = ± .01
.XXX = ± .005
.XXXX = ± .0005
X°±1°
X/X ±1/32
ALL MACHINED SURFACES 63
THIRD ANGLE PROJECTION
DRAWN BY
KEITH STOLWORTHY
DATE
Q.A.
DATE
SCALE
NTS
CHECKED BY
DATE
PROD. REL.
DATE
PTM FILENAME
ST_04_000
PART NAME:
ELECTRONICS MOUNT
DWG SIZE
A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO.
ST_04_000
REV.
A
CONTROLLED
INIT.
DATE
UNCONTROLLED
INIT.
DATE

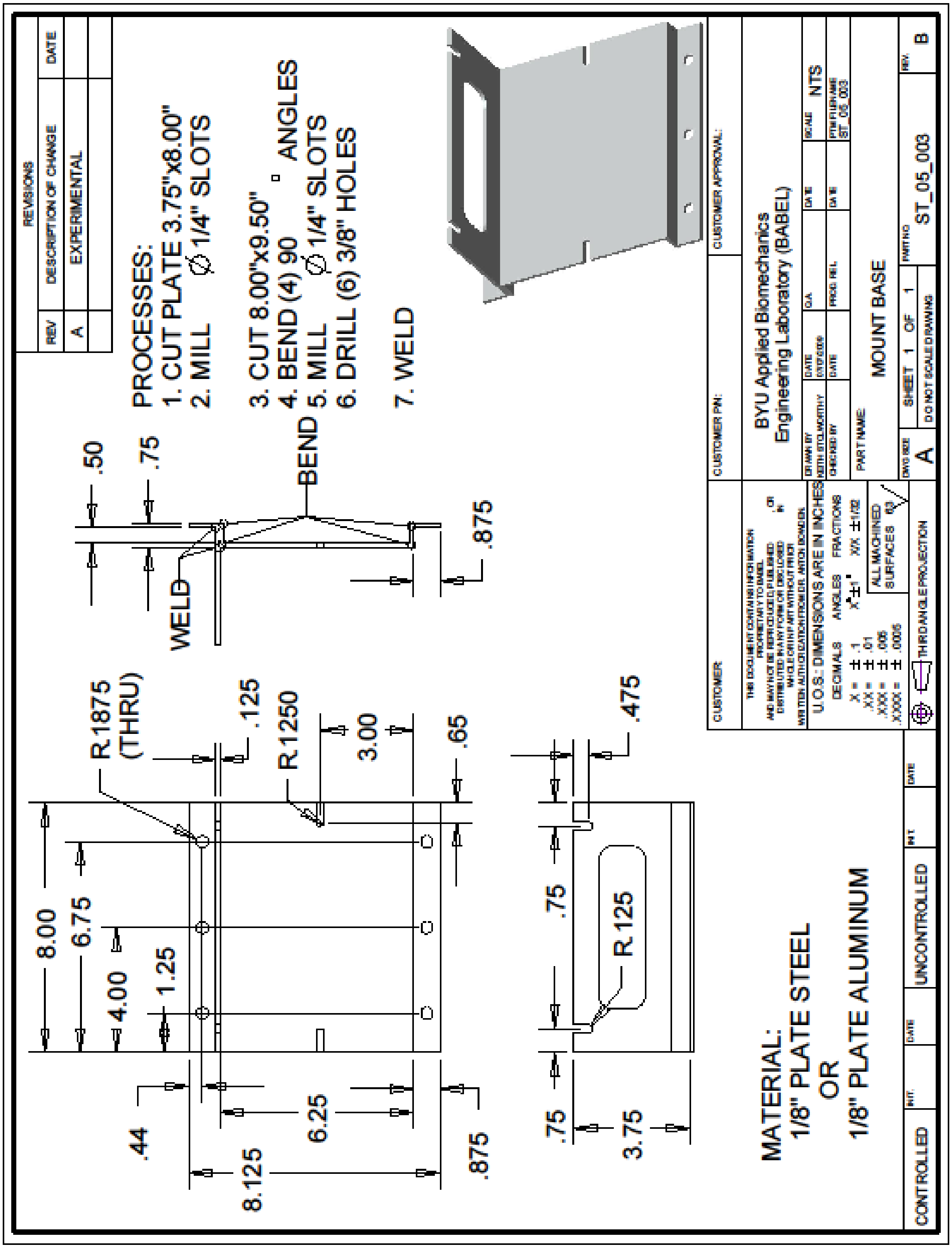

REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
SCALE 0.125
SECTION A-A
SECTION B-B
1.50
3.125
2.75
2.75
2.31 (TYP)
.81 (TYP)
.625 (TYP)
R.094
.35
PROCESSES:
1. CUT 8.00"x15.75"
2. DRILL HOLES
3. BEND **NOTE VIEW HOLES ARE NOT REQUIRED
1.90
.40
.25
R.50 (TYP)
5.25 (TYP)
3.75
2.63
1.95
.67
.63
.25 (TYP)
R.094 (TYP)
R.0625 (TYP)
.625
2.375
R.094 (TYP)
MATERIAL:
1/8" SHEET ALUMINUM
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
PART NAME:
CONTROLLER MOUNT
SCALE NTS
SHEET 1 OF 1
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
A
ST_04_001
B
CONTROLLED
UNCONTROLLED



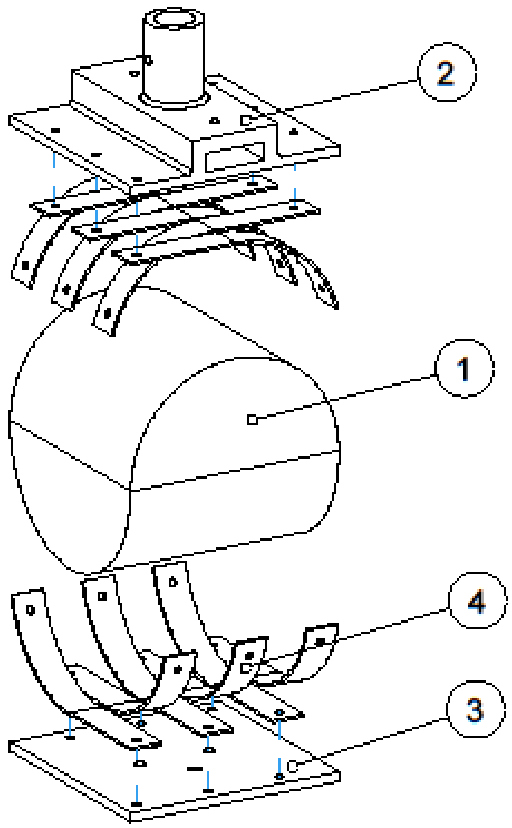
REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
SECTION A-A
1.375
1.375
R.109 (TYP)
Ø1.375
Ø1.772
.75
.75
2.00
.50
.40
7.30
(5.80)
2.75
1.375
R.079 (TYP)
1.50
R.50
15.0°
30.0°
R.188
Ø1.575
SECTION A-A
.75
(2.75)
(7.05)
A
A
BEND
1.58
.61
2.14
.82
1.93
1.17
.82
.82
SECTION A-A
MATERIAL:
1/8" SHEET ALUMINUM
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
THIRD ANGLE PROJECTION
DRAWN BY
CHECKED BY
PART NAME:
MOTOR MOUNT
SCALE
NTS
ST_04_002
SHEET 1 OF 1
DO NOT SCALE DRAWING
DWG SIZE
A
PART NO.
ST_04_002
REV.
B
CONTROLLED
UNCONTROLLED

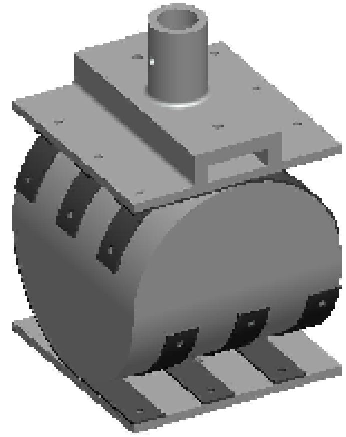

REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
1
2
3
SCALE 0.100
| PART NO. | PART NAME | QUANT
1 | ST_05_001 | TABLE MOUNT | 1
2 | ST_05_002* | WEIGHT** | 1**
3 | ST_05_003 | MOUNT BASE | 1
* DRAWING ST_05_002 D.N.E. UNNECESSARY
** WEIGHTS ARE VARIABLE
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
DRAWN BY
KEITH STOLWORTHY
CHECKED BY
PART NAME:
MOUNTING SUBASSEMBLY
SCALE NTS
ST_05_000
THIRD ANGLE PROJECTION
DWG SIZE A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO
ST_05_000
REV. A
CONTROLLED
UNCONTROLLED


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
50.00
(REQUIRED MINIMUM LENGTH)
(30.00)
MINIMUM DESIRED DEPTH = 24
ON MIDLINE
10.00
(REQUIRED)
SCALE 0.100
MATERIAL:
TABLE SURFACE W/ APPROXIMATE
THICKNESS OF 0.75".
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
SCALE NTS
PART NAME:
TABLE MOUNT
SHEET 1 OF 1
DO NOT SCALE DRAWING
ST_05_001
A
THIRD ANGLE PROJECTION
CONTROLLED
UNCONTROLLED


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
PROCESSES:
1. CUT PLATE 3.75"x8.00"
2. MILL Ø 1/4" SLOTS
3. CUT 8.00"x9.50"
4. BEND (4) 90 ° ANGLES
5. MILL Ø 1/4" SLOTS
6. DRILL (6) 3/8" HOLES
7. WELD
.50
.75
BEND
WELD
.875
R.1875 (THRU)
.125
R.1250
3.00
.65
.475
8.00
6.75
4.00
1.25
.44
8.125
6.25
.875
.75
R.125
.75
3.75
MATERIAL:
1/8" PLATE STEEL
OR
1/8" PLATE ALUMINUM
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
THIRD ANGLE PROJECTION
DRAWN BY
CHECKED BY
PART NAME
MOUNT BASE
SCALE
NTS
SHEET 1 OF 1
DO NOT SCALE DRAWING
DWG SIZE
A
PART NO.
ST_05_003
REV.
B
CONTROLLED
UNCONTROLLED

REV	DESCRIPTION OF CHANGE	DATE
A	EXPERIMENTAL	





Note: This design is the beginning stages of a compliant mechanism universal joint, and was not used in the construction of MASSUCE. Rather, a standard universal joint from an automotive steering linkage was used.

#	PART NO.	PART NAME	QUANT
1	ST_06_001	CORE BODY	1*
2	ST_06_002_1	AXIS-LEVER PLATE	1
3	ST_06_002_2	TORQUE MOUNT PLATE	1
4	ST_06_003	SPRING STEEL	12**

* ALSO USED IN ST_07_000, TOTAL USED EQUALS 2.

** ALSO USED IN ST_07_000, TOTAL USED EQUALS 24.

CUSTOMER: | CUSTOMER P/N: | CUSTOMER APPROVAL:

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BYU Applied Biomechanics Engineering Laboratory (BABEL)

U.O.S.: DIMENSIONS ARE IN INCHES

DECIMALS: .X = ± .1; .XX = ± .01; .XXX = ± .005; .XXXX = ± .0005
ANGLES: X° ±1°
FRACTIONS: X/X ±1/32
ALL MACHINED SURFACES 63

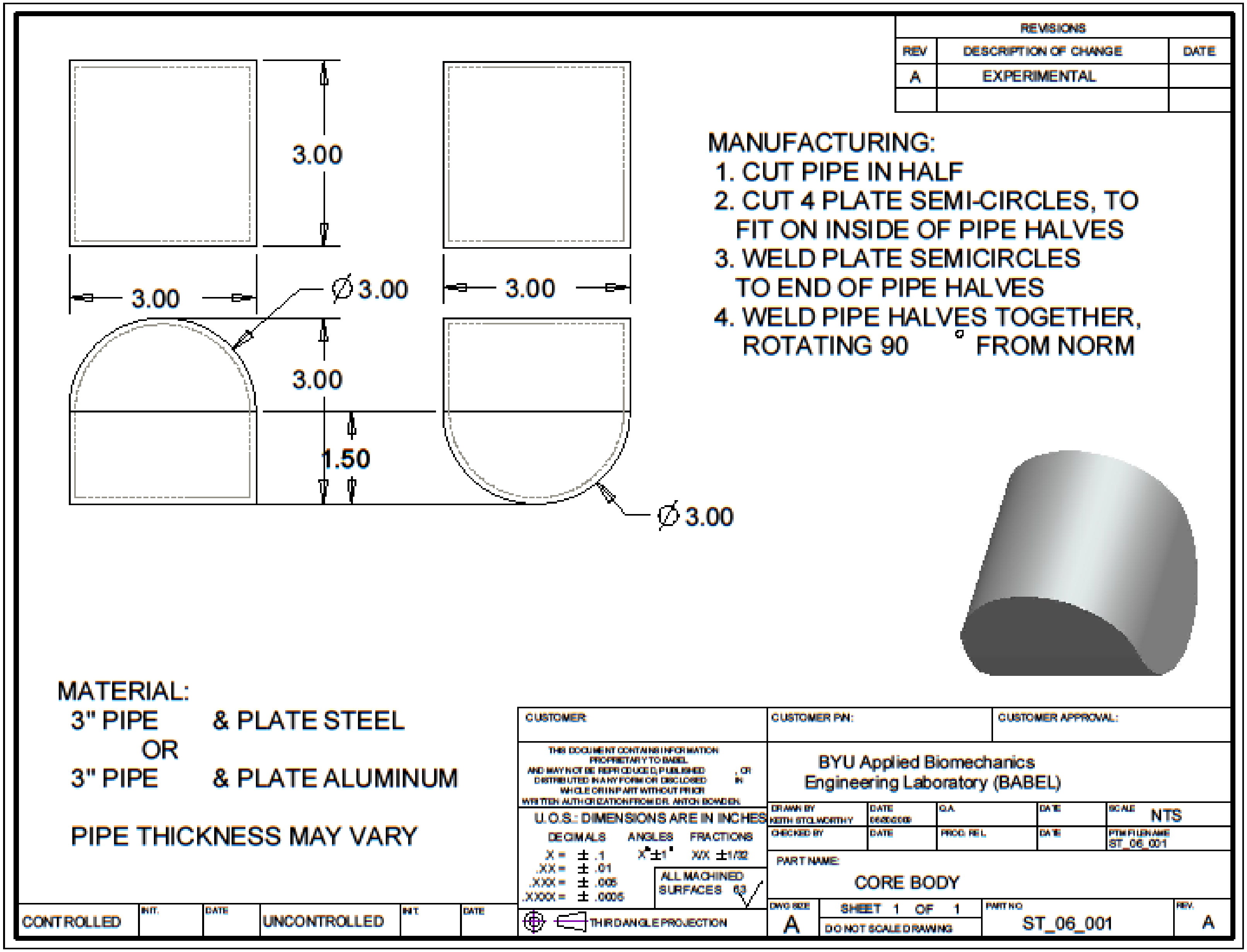
DRAWN BY: KEITH STOLWORTHY | DATE | Q.A. | DATE | SCALE: NTS
CHECKED BY | DATE | PROD. REL. | DATE | PTM FILENAME: ST_06_000

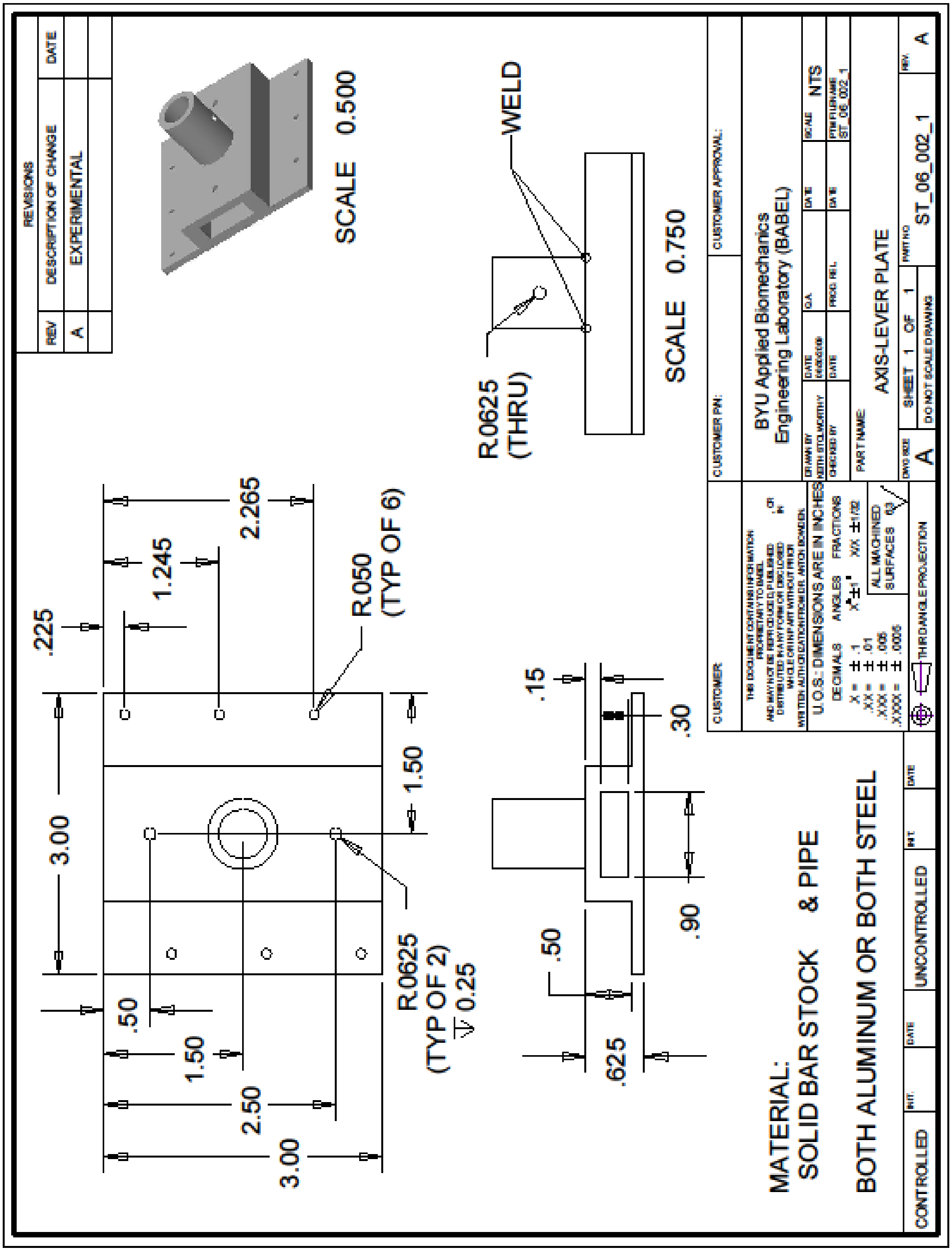
PART NAME: CORE U-JOINT 1 SUBASSEMBLY

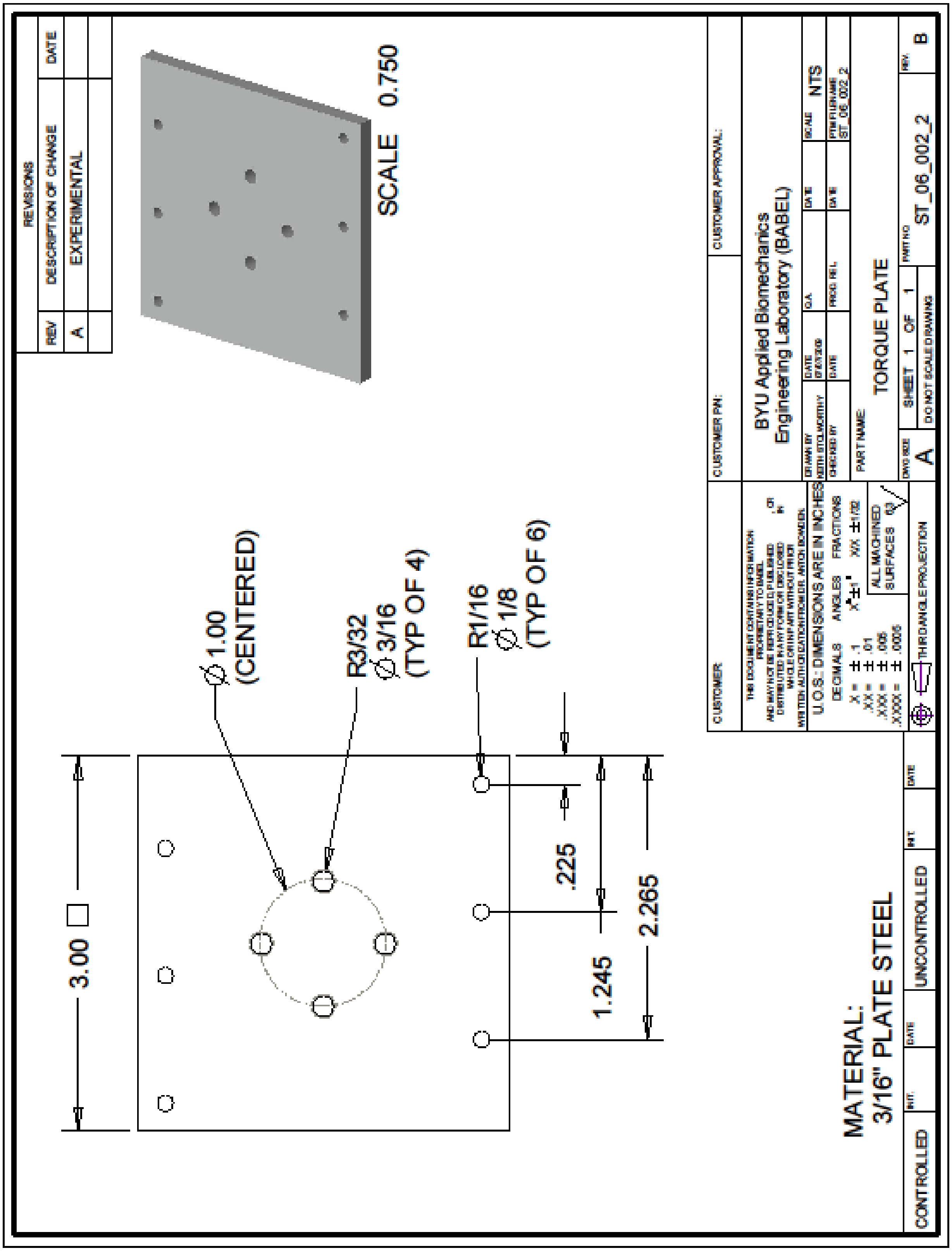
DWG SIZE: A | SHEET 1 OF 1 | DO NOT SCALE DRAWING | PART NO.: ST_06_000 | REV.: A

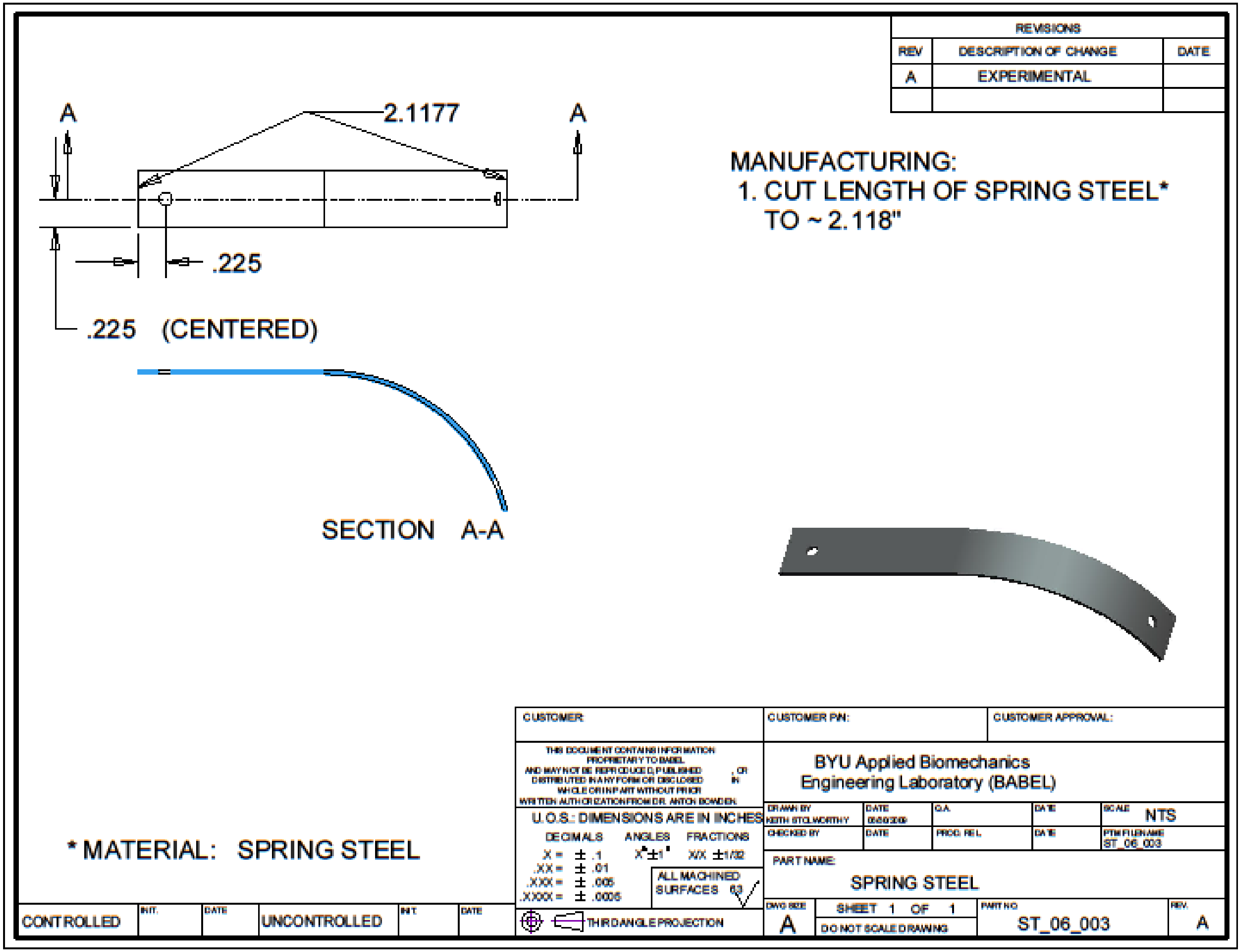
THIRD ANGLE PROJECTION

CONTROLLED | INIT. | DATE | UNCONTROLLED | INIT. | DATE


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
3.00
3.00
Ø3.00
3.00
3.00
1.50
3.00
Ø3.00
MANUFACTURING:
1. CUT PIPE IN HALF
2. CUT 4 PLATE SEMI-CIRCLES, TO FIT ON INSIDE OF PIPE HALVES
3. WELD PLATE SEMICIRCLES TO END OF PIPE HALVES
4. WELD PIPE HALVES TOGETHER, ROTATING 90° FROM NORM
MATERIAL:
3" PIPE & PLATE STEEL
OR
3" PIPE & PLATE ALUMINUM
PIPE THICKNESS MAY VARY
CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
.X = ± .1
.XX = ± .01
.XXX = ± .005
.XXXX = ± .0005
X°±1°
X/X ±1/32
ALL MACHINED SURFACES 63
DRAWN BY
DATE
Q.A.
DATE
SCALE
NTS
CHECKED BY
DATE
PROD. REL.
DATE
PART NAME:
CORE BODY
DWG SIZE
A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO.
ST_06_001
REV.
A
CONTROLLED
INIT.
DATE
UNCONTROLLED
INIT.
DATE
THIRD ANGLE PROJECTION


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
SCALE 0.500
WELD
R.0625
(THRU)
SCALE 0.750
3.00
.225
1.245
2.265
R.050
(TYP OF 6)
1.50
.50
1.50
2.50
3.00
R.0625
(TYP OF 2)
0.25
.15
.30
.50
.90
.625
MATERIAL:
SOLID BAR STOCK & PIPE
BOTH ALUMINUM OR BOTH STEEL
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
SCALE
NTS
PART NAME:
AXIS-LEVER PLATE
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO.
ST_06_002_1
A
A
THIRD ANGLE PROJECTION
CONTROLLED
UNCONTROLLED


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
SCALE 0.750
3.00 □
∅1.00
(CENTERED)
R3/32
∅3/16
(TYP OF 4)
R1/16
∅1/8
(TYP OF 6)
.225
1.245
2.265
MATERIAL:
3/16" PLATE STEEL
CONTROLLED
UNCONTROLLED
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
THIRD ANGLE PROJECTION
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
DRAWN BY
CHECKED BY
Q.A.
PROD. REL.
SCALE
NTS
PART NAME:
TORQUE PLATE
DWG SIZE
A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO.
ST_06_002_2
REV.
B



REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
A
2.1177
A
.225
.225 (CENTERED)
SECTION A-A
MANUFACTURING:
1. CUT LENGTH OF SPRING STEEL*
TO ~ 2.118"
* MATERIAL: SPRING STEEL
CONTROLLED
INIT.
DATE
UNCONTROLLED
INIT.
DATE
CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:
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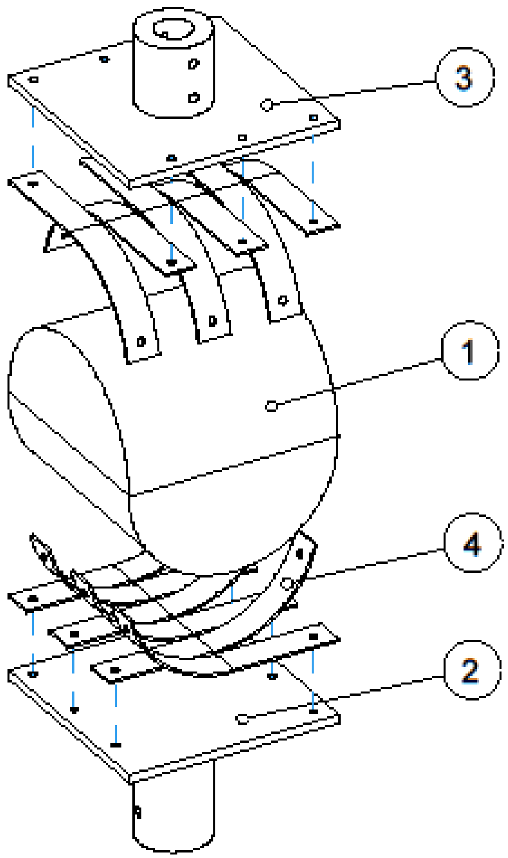
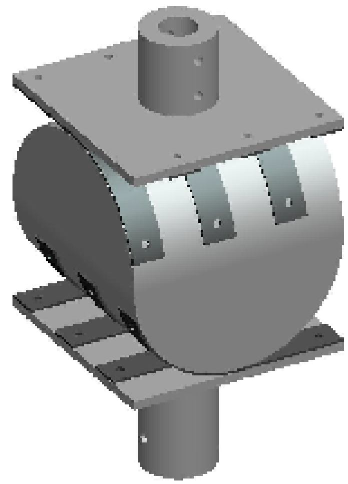
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
.X = ± .1
.XX = ± .01
.XXX = ± .005
.XXXX = ± .0005
X° ±1°
X/X ±1/32
ALL MACHINED SURFACES 63
THIRD ANGLE PROJECTION
DRAWN BY
KEITH STOLWORTHY
DATE
Q.A.
DATE
SCALE
NTS
CHECKED BY
DATE
PROD. REL.
DATE
PTM FILENAME
ST_06_003
PART NAME:
SPRING STEEL
DWG SIZE
A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO
ST_06_003
REV.
A

REVISIONS		
REV	DESCRIPTION OF CHANGE	DATE
A	EXPERIMENTAL	





SCALE 0.500

Note: This design is the beginning stages of a compliant mechanism universal joint, and was not used in the construction of MASSUCE. Rather, a standard universal joint from an automotive steering linkage was used.

#	PART NO.	PART NAME	QUANT
1	ST_06_001	CORE BODY	1*
2	ST_07_002_1	DRIVE PLATE	1
3	ST_07_002_2	MOTOR PLATE	1
4	ST_06_003	SPRING STEEL	12**

* ALSO USED IN ST_06_000, TOTAL USED EQUALS 2.

** ALSO USED IN ST_06_000, TOTAL USED EQUALS 24.

CUSTOMER: CUSTOMER P/N: CUSTOMER APPROVAL:

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U.O.S.: DIMENSIONS ARE IN INCHES

DECIMALS: .X = ± .1, .XX = ± .01, .XXX = ± .005, .XXXX = ± .0005 ANGLES: X°±1° FRACTIONS: X/X ±1/32

ALL MACHINED SURFACES 63

THIRD ANGLE PROJECTION

BYU Applied Biomechanics Engineering Laboratory (BABEL)

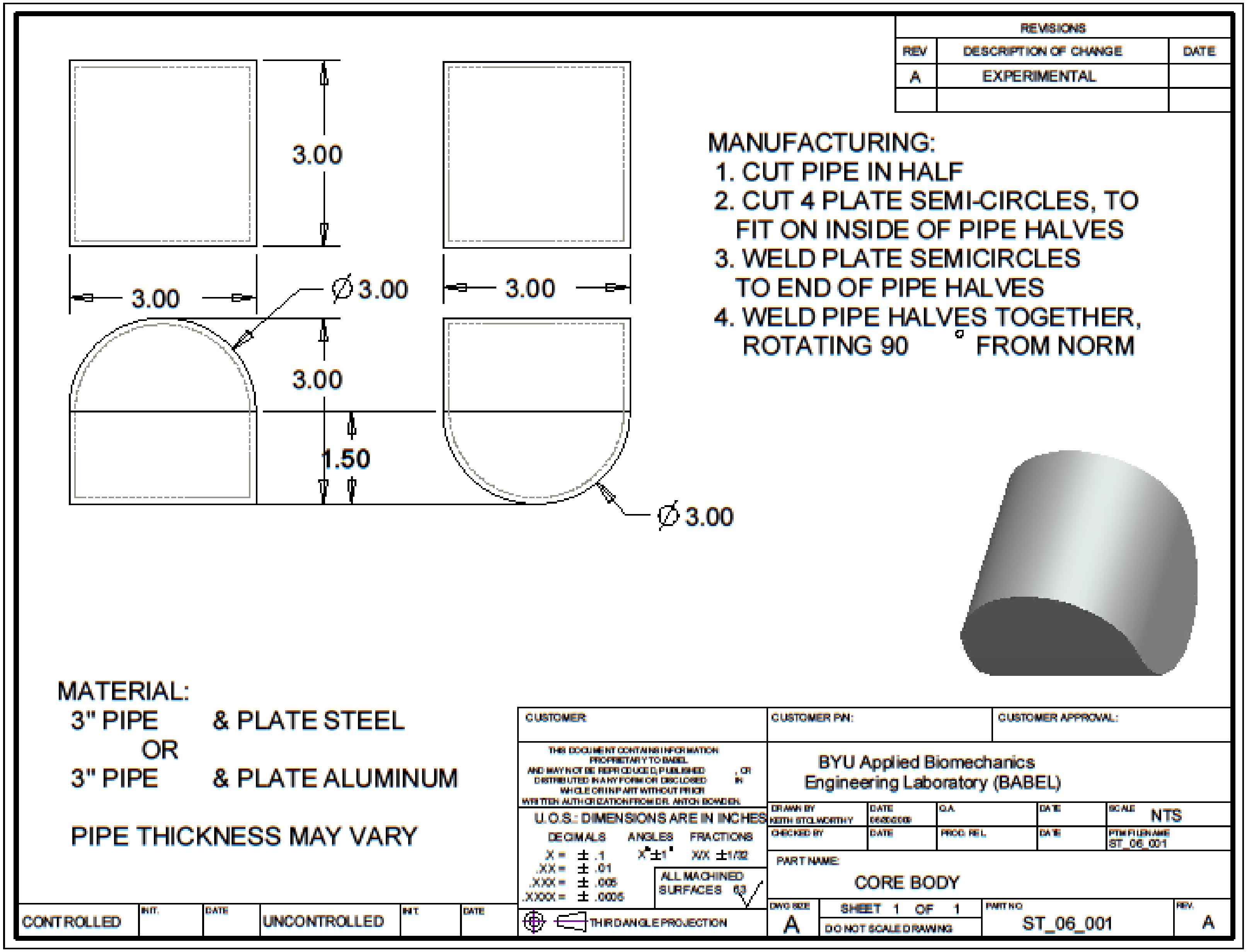
DRAWN BY: KEITH STOLWORTHY DATE: 05/20/09 Q.A. DATE SCALE: NTS

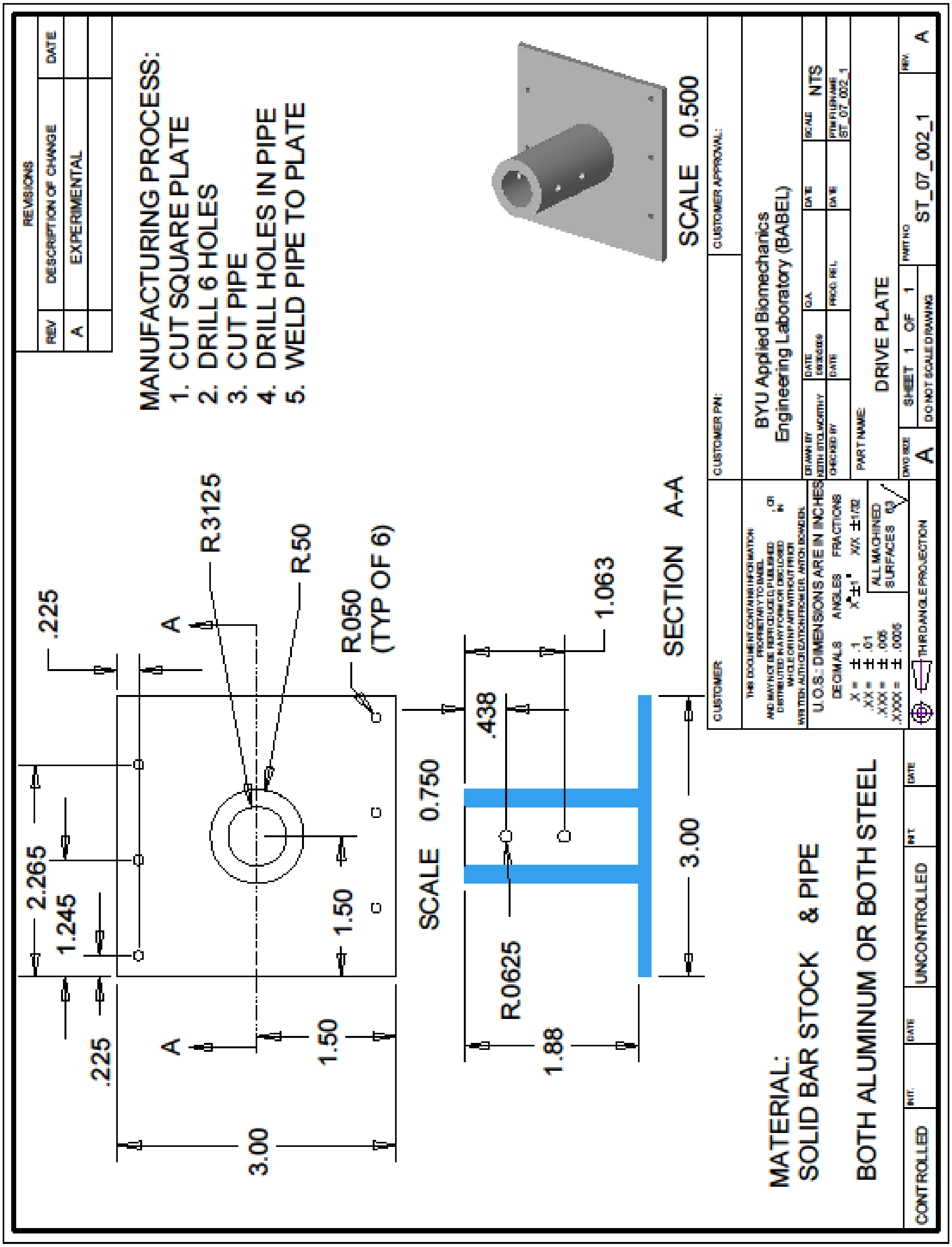
CHECKED BY DATE PROD. REL. DATE PTM FILENAME: ST_07_000

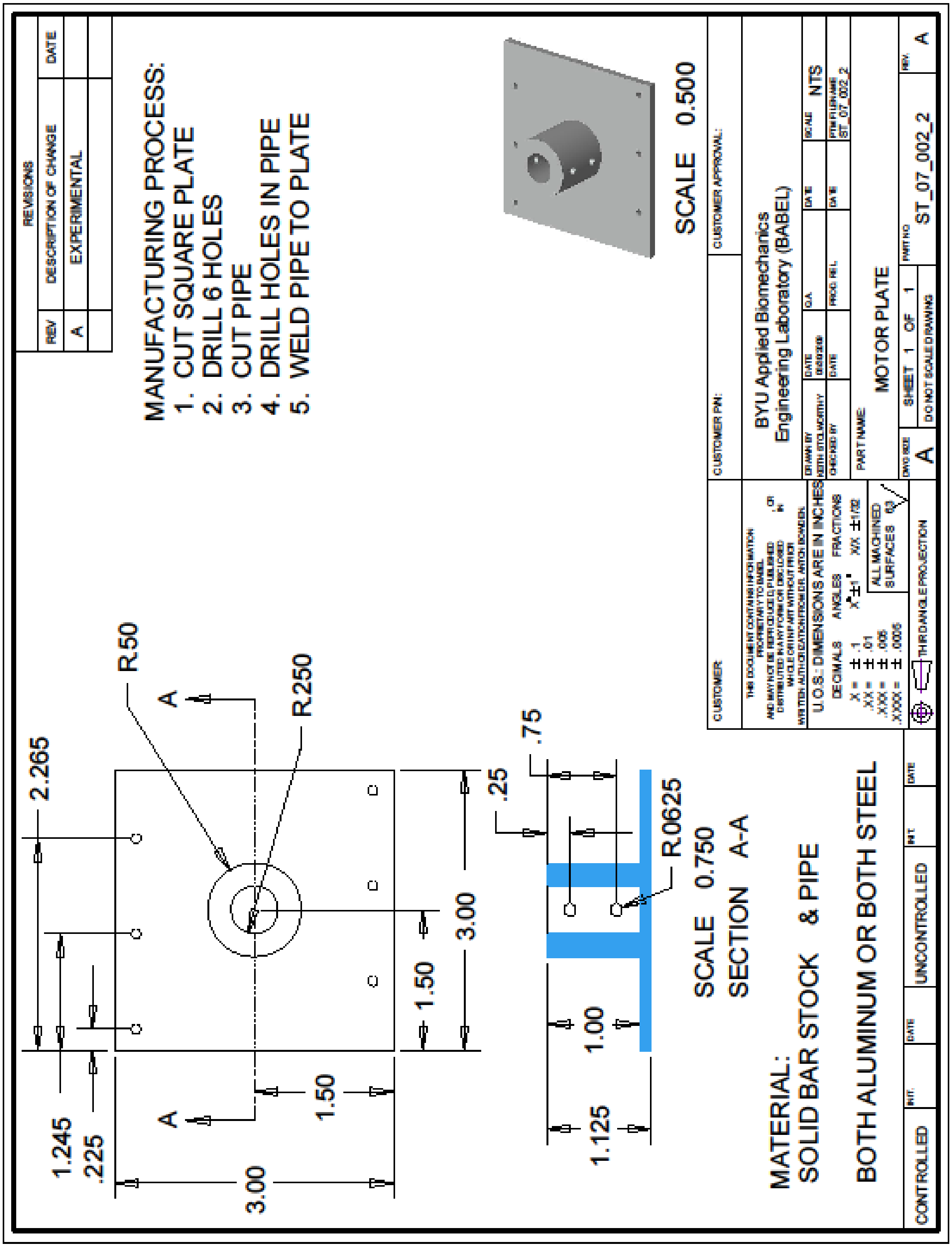
PART NAME: CORE U-JOINT 2 SUBASSEMBLY

DWG SIZE: A SHEET 1 OF 1 DO NOT SCALE DRAWING PART NO: ST_07_000 REV. A

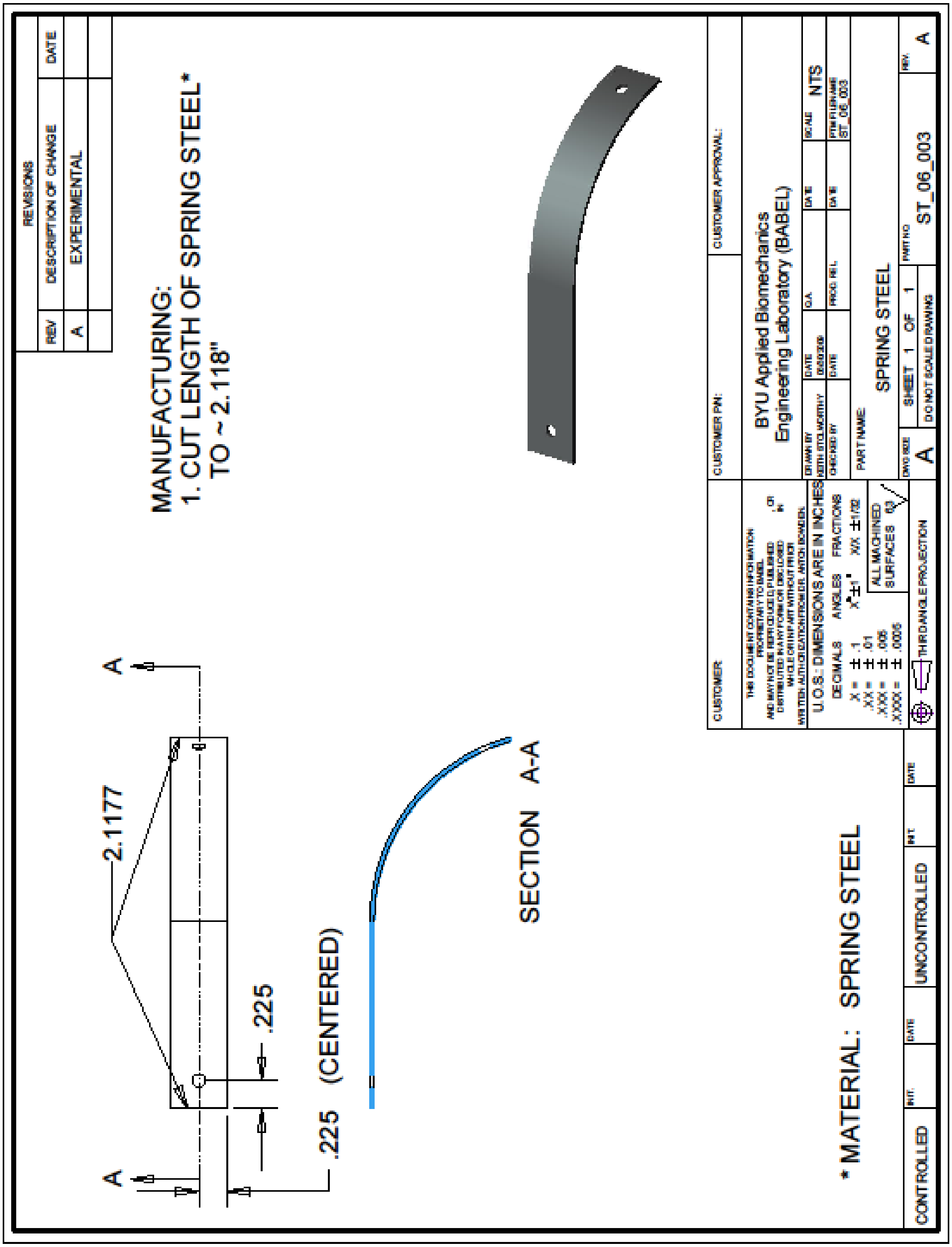
CONTROLLED INIT. DATE UNCONTROLLED INIT. DATE

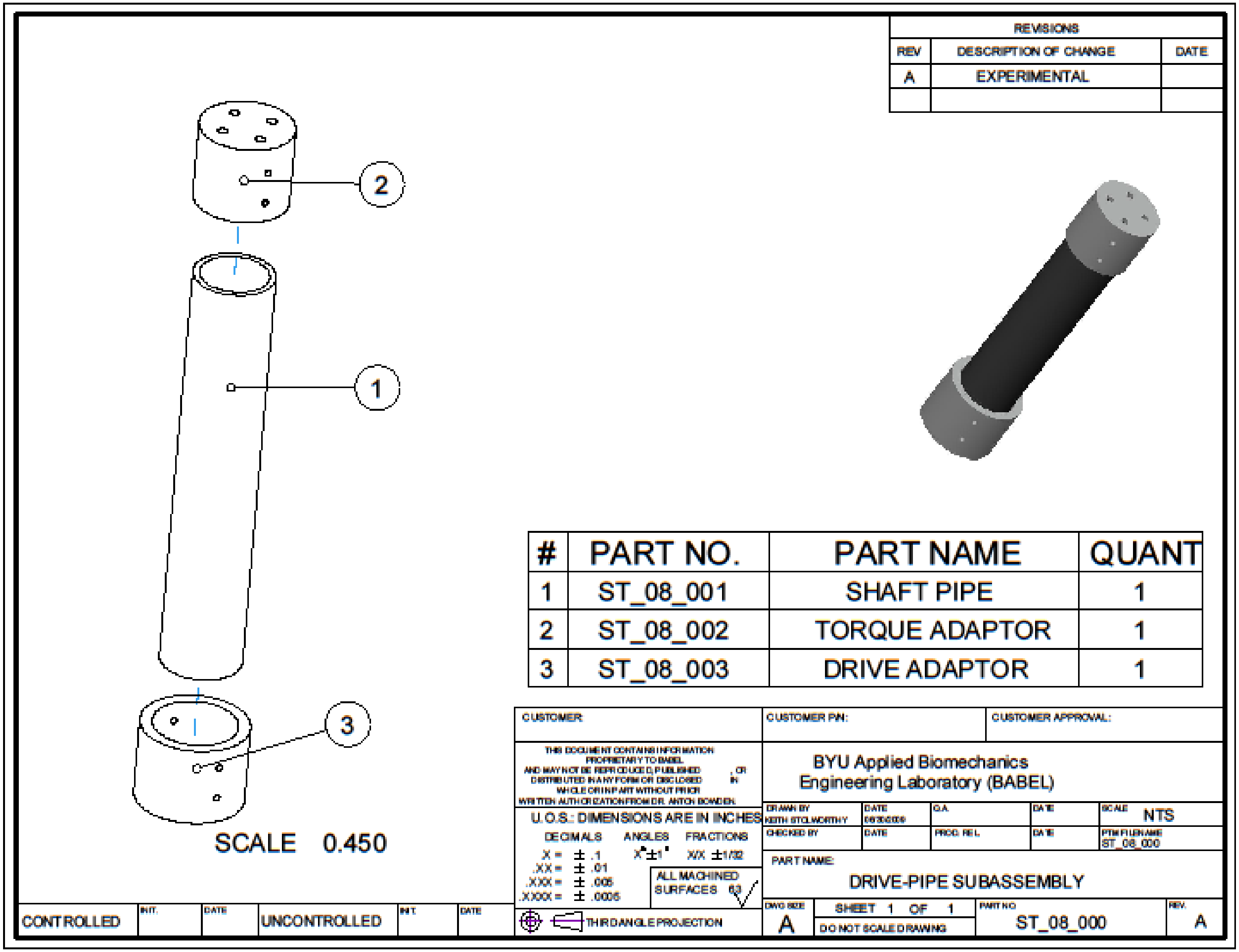

REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
3.00
3.00
Ø 3.00
3.00
3.00
1.50
3.00
Ø 3.00
MANUFACTURING:
1. CUT PIPE IN HALF
2. CUT 4 PLATE SEMI-CIRCLES, TO FIT ON INSIDE OF PIPE HALVES
3. WELD PLATE SEMICIRCLES TO END OF PIPE HALVES
4. WELD PIPE HALVES TOGETHER, ROTATING 90 ° FROM NORM
MATERIAL:
3" PIPE & PLATE STEEL
OR
3" PIPE & PLATE ALUMINUM
PIPE THICKNESS MAY VARY
CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
SCALE
NTS
PART NAME:
CORE BODY
DWG SIZE
A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO.
ST_06_001
REV.
A
CONTROLLED
UNCONTROLLED
THIRD ANGLE PROJECTION


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
MANUFACTURING PROCESS:
1. CUT SQUARE PLATE
2. DRILL 6 HOLES
3. CUT PIPE
4. DRILL HOLES IN PIPE
5. WELD PIPE TO PLATE
SCALE 0.500
.225
2.265
1.245
.225
A
A
R.3125
R.50
R.050
(TYP OF 6)
1.50
1.50
3.00
SCALE 0.750
.438
1.063
R.0625
1.88
3.00
SECTION A-A
MATERIAL:
SOLID BAR STOCK & PIPE
BOTH ALUMINUM OR BOTH STEEL
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
DRAWN BY
KEITH STOLWORTHY
CHECKED BY
DATE
Q.A.
PROD. REL.
SCALE
NTS
PART NAME:
DRIVE PLATE
DWG SIZE
A
SHEET 1 OF 1
PART NO.
ST_07_002_1
REV.
A
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
CONTROLLED
UNCONTROLLED

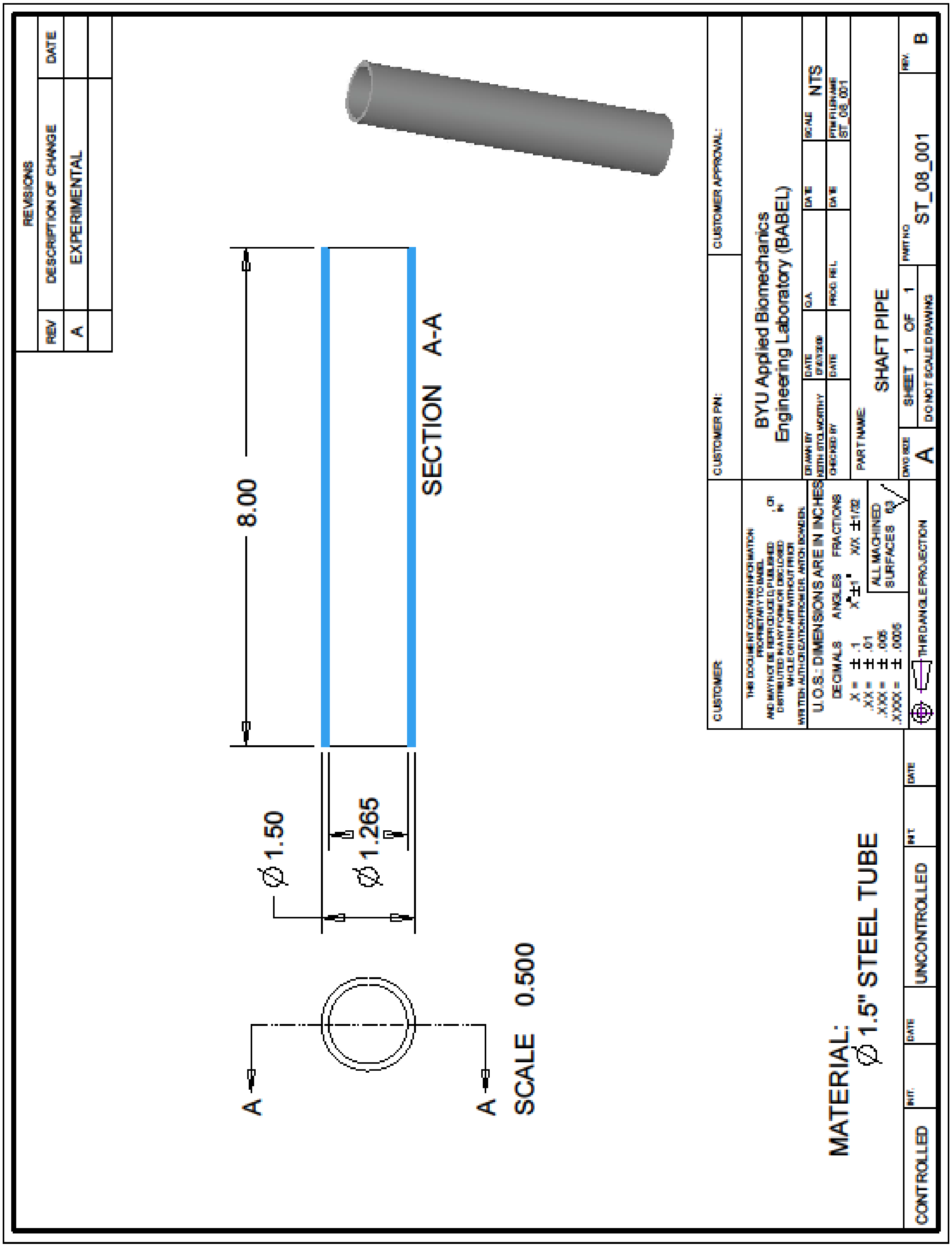


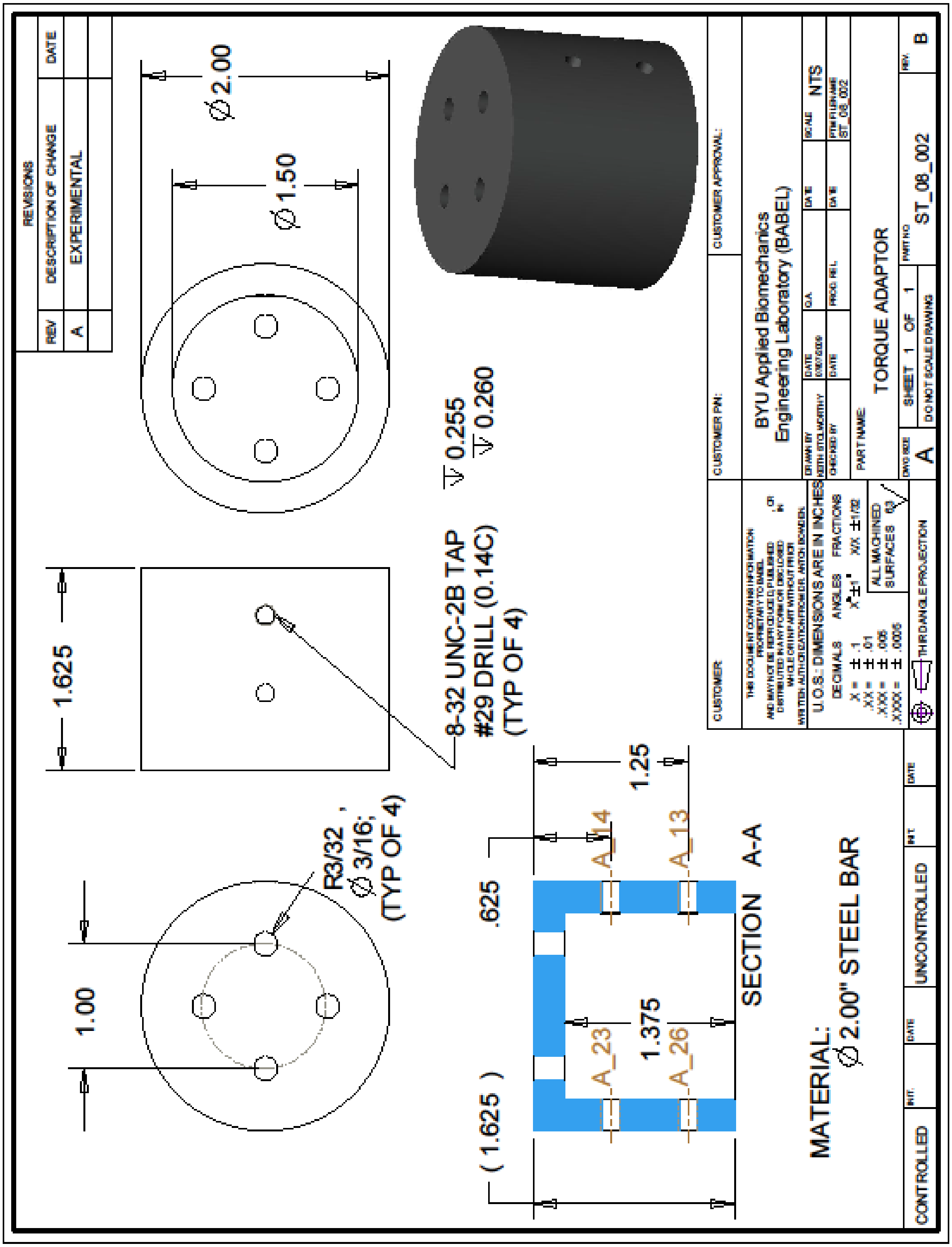
MANUFACTURING PROCESS:
1. CUT SQUARE PLATE
2. DRILL 6 HOLES
3. CUT PIPE
4. DRILL HOLES IN PIPE
5. WELD PIPE TO PLATE
REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
SCALE 0.500
R.50
R.250
2.265
1.245
.225
3.00
1.50
1.50
3.00
A
A
.25
.75
1.00
1.125
R.0625
SCALE 0.750
SECTION A-A
MATERIAL:
SOLID BAR STOCK & PIPE
BOTH ALUMINUM OR BOTH STEEL
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
PART NAME:
MOTOR PLATE
SHEET 1 OF 1
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
NTS
ST_07_002_2
A
A
CONTROLLED
UNCONTROLLED


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
MANUFACTURING:
1. CUT LENGTH OF SPRING STEEL*
TO ~ 2.118"
A
2.1177
A
.225
.225 (CENTERED)
SECTION A-A
* MATERIAL: SPRING STEEL
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
DRAWN BY
CHECKED BY
DATE
Q.A.
PROD. REL.
SCALE
NTS
PART NAME:
SPRING STEEL
DWG SIZE
A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO.
ST_06_003
REV.
A
THIRD ANGLE PROJECTION
CONTROLLED
INIT.
DATE
UNCONTROLLED

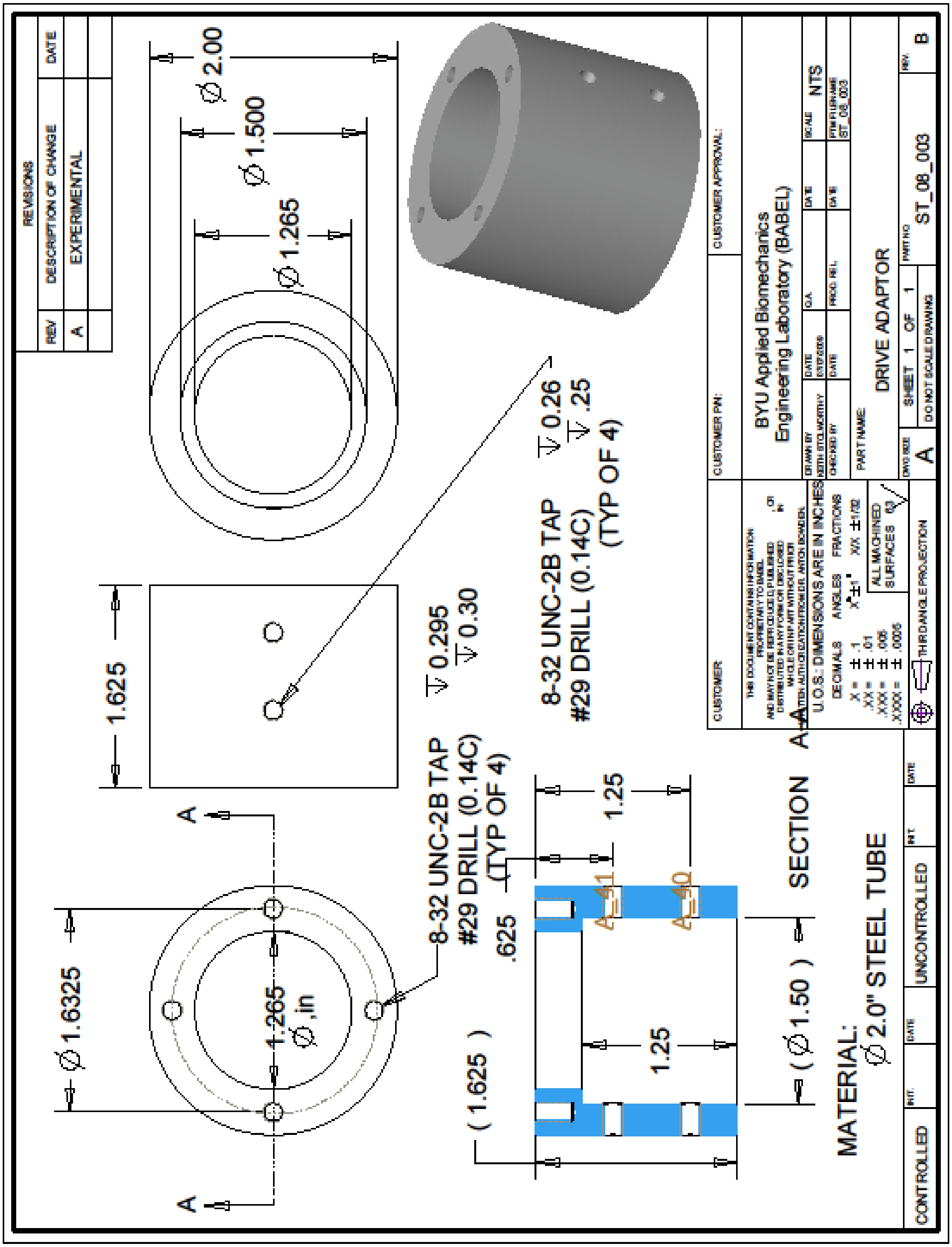


#	PART NO.	PART NAME	QUANT
1	ST_08_001	SHAFT PIPE	1
2	ST_08_002	TORQUE ADAPTOR	1
3	ST_08_003	DRIVE ADAPTOR	1

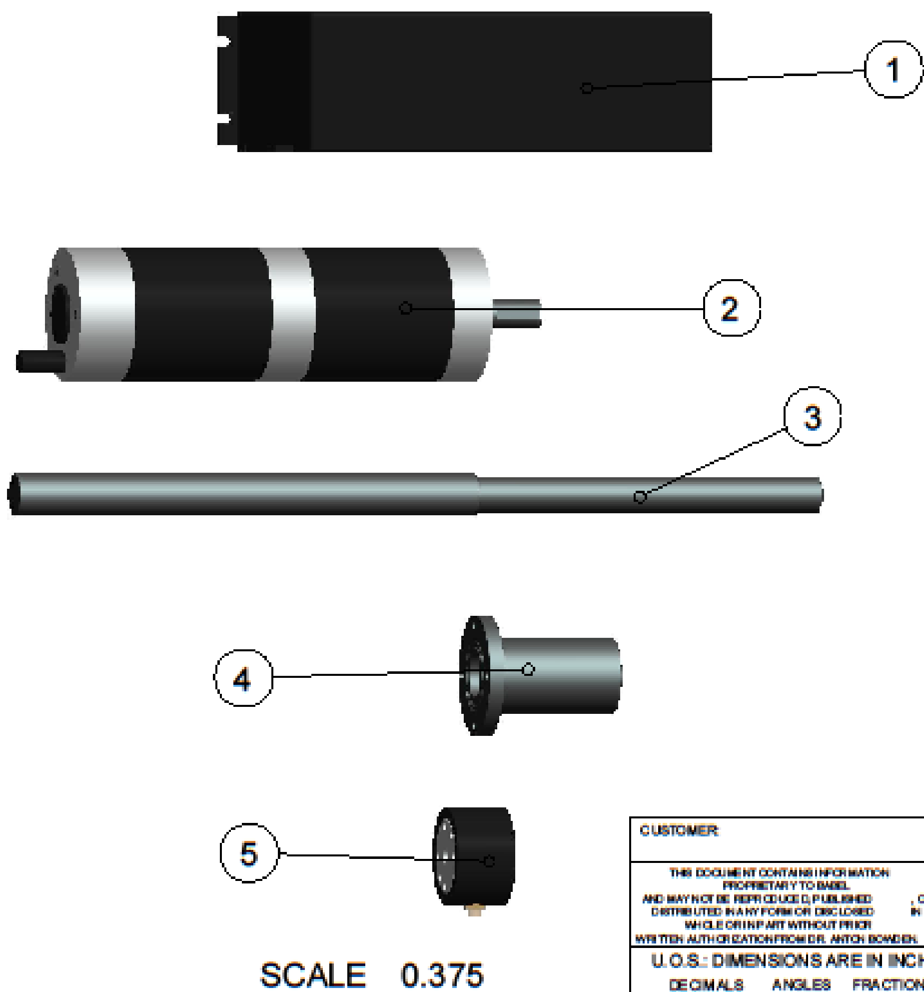

REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
8.00
SECTION A-A
Ø1.50
Ø1.265
A
A
SCALE 0.500
MATERIAL:
Ø1.5" STEEL TUBE
CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
PART NAME:
SHAFT PIPE
SCALE
NTS
SHEET 1 OF 1
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
DWG SIZE
A
PART NO.
ST_08_001
REV.
B
CONTROLLED
UNCONTROLLED



REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
Ø2.00
Ø1.50
1.625
1.00
R3/32 ,
Ø 3/16;
(TYP OF 4)
8-32 UNC-2B TAP
#29 DRILL (0.14C)
(TYP OF 4)
▽ 0.255
▽ 0.260
(1.625)
.625
1.25
1.375
A_14
A_13
A_23
A_26
SECTION A-A
MATERIAL:
Ø 2.00" STEEL BAR
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
DRAWN BY
CHECKED BY
DATE
Q.A.
PROD. REL.
SCALE
NTS
PART NAME:
TORQUE ADAPTOR
SHEET 1 OF 1
DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
DWG SIZE
A
PART NO.
ST_08_002
REV.
B
CONTROLLED
INIT.
DATE
UNCONTROLLED
INIT.
DATE


REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
Ø2.00
Ø1.500
Ø1.265
Ø1.6325
1.265
Ø ,in
1.625
A
A
8-32 UNC-2B TAP
#29 DRILL (0.14C)
(TYP OF 4)
.625
(1.625)
1.25
1.25
(Ø1.50)
SECTION A-A
∇ 0.295
∇ 0.30
8-32 UNC-2B TAP
#29 DRILL (0.14C)
(TYP OF 4)
∇ 0.26
∇ .25
MATERIAL:
Ø2.0" STEEL TUBE
CUSTOMER
CUSTOMER P/N:
CUSTOMER APPROVAL:
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES
THIRD ANGLE PROJECTION
DRAWN BY
CHECKED BY
DATE
Q.A.
PROD. REL.
SCALE
NTS
PART NAME:
DRIVE ADAPTOR
SHEET 1 OF 1
DO NOT SCALE DRAWING
DWG SIZE
A
PART NO.
ST_08_003
REV.
B
CONTROLLED
INIT.
DATE
UNCONTROLLED
INIT.
DATE

REV	DESCRIPTION OF CHANGE	DATE
A	EXPERIMENTAL	



#	EQUIPMENT NAME	QUANT
1	MOTOR CONTROL	1
2	MOTOR/GEARBOX	1
3	DRIVE SHAFT	1
4	ROLLER SHAFT	1
5	TORQUE SENSOR	1

CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:

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BYU Applied Biomechanics Engineering Laboratory (BABEL)

U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS: .X = ± .1; .XX = ± .01; .XXX = ± .005; .XXXX = ± .0005
ANGLES: X° ± 1°
FRACTIONS: X/X ± 1/32
ALL MACHINED SURFACES 63

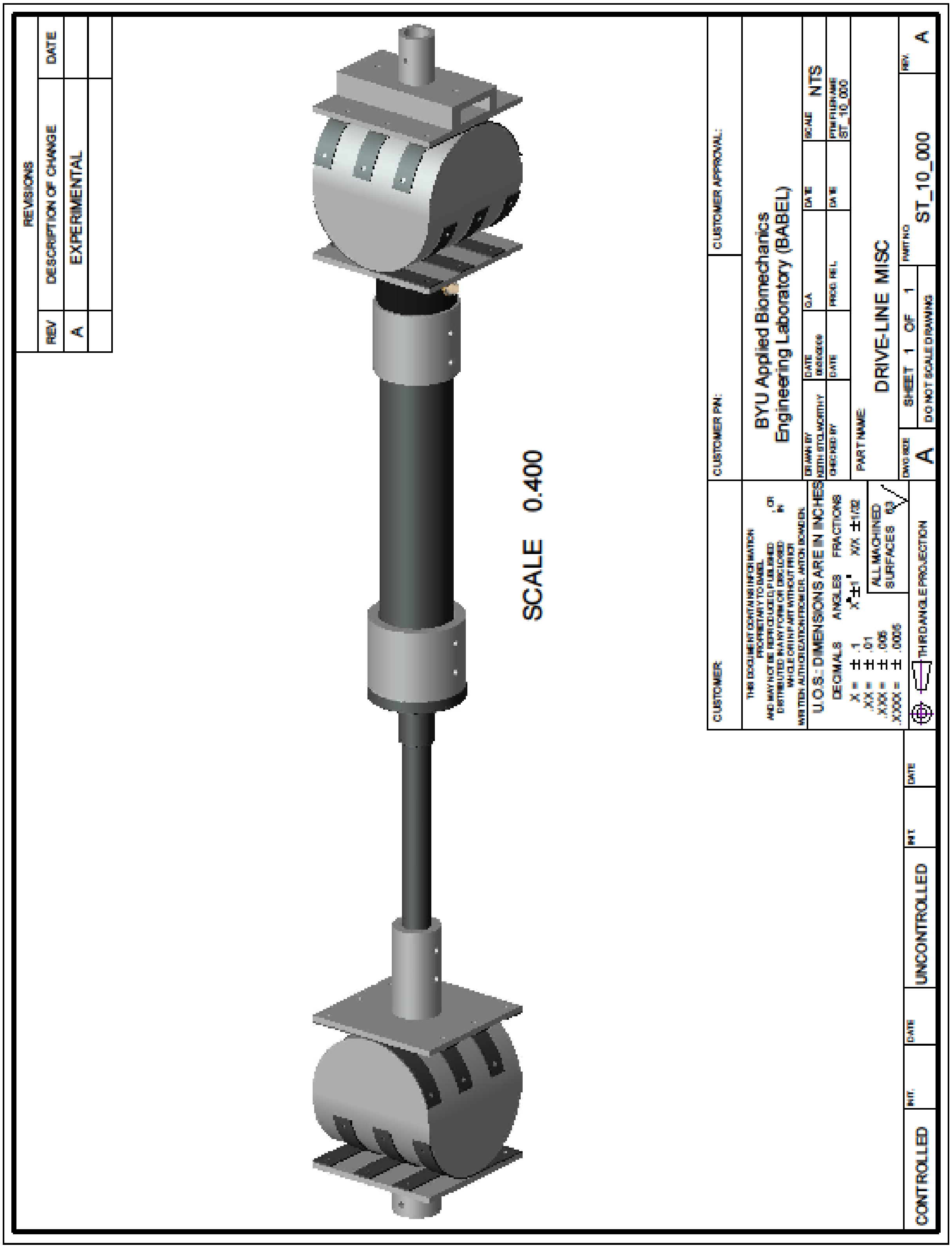
DRAWN BY: KEITH STOLWORTHY | DATE: 05/05/09 | Q.A. | DATE | SCALE: NTS
CHECKED BY | DATE | PROD. REL. | DATE | PTM FILENAME: ST_09_000

PART NAME: PURCHASED EQUIPMENT - MISC

THIRD ANGLE PROJECTION

DWG SIZE: A | SHEET 1 OF 1 | DO NOT SCALE DRAWING | PART NO: ST_09_000 | REV: A

CONTROLLED | INIT. | DATE | UNCONTROLLED | INIT. | DATE



REVISIONS
REV
DESCRIPTION OF CHANGE
DATE
A
EXPERIMENTAL
SCALE 0.400
CUSTOMER:
CUSTOMER P/N:
CUSTOMER APPROVAL:
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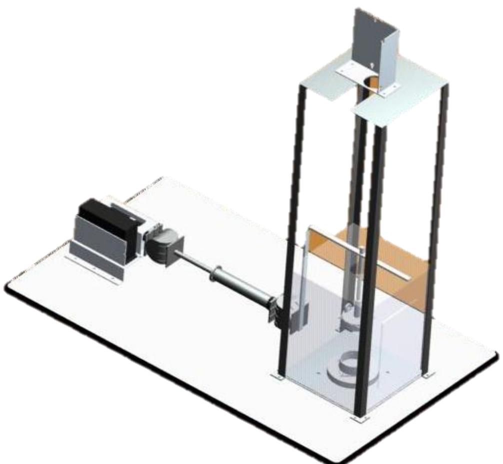
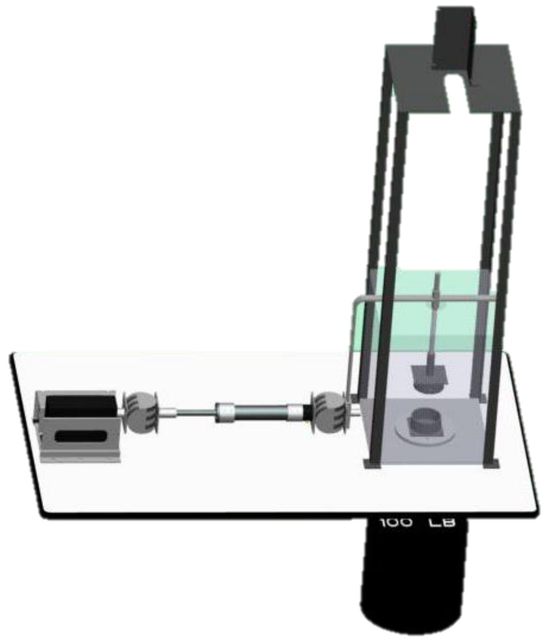
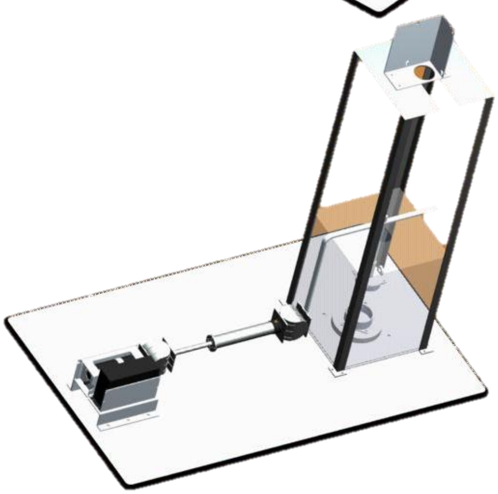
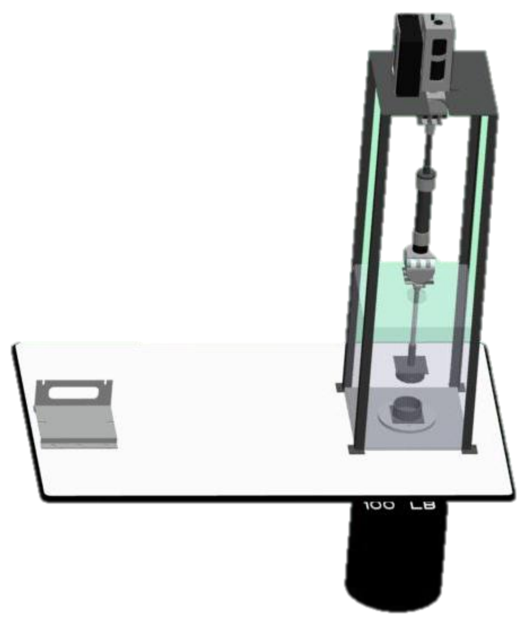
BYU Applied Biomechanics
Engineering Laboratory (BABEL)
U.O.S.: DIMENSIONS ARE IN INCHES
DECIMALS
ANGLES
FRACTIONS
ALL MACHINED SURFACES 63
THIRD ANGLE PROJECTION
DRAWN BY
KEITH STOLWORTHY
CHECKED BY
DATE
Q.A.
PROD. REL.
SCALE
NTS
PTW FILE NAME
ST_10_000
PART NAME
DRIVE-LINE MISC
DWG SIZE
A
SHEET 1 OF 1
DO NOT SCALE DRAWING
PART NO.
ST_10_000
REV.
A
CONTROLLED
INIT.
DATE
UNCONTROLLED
INIT.
DATE

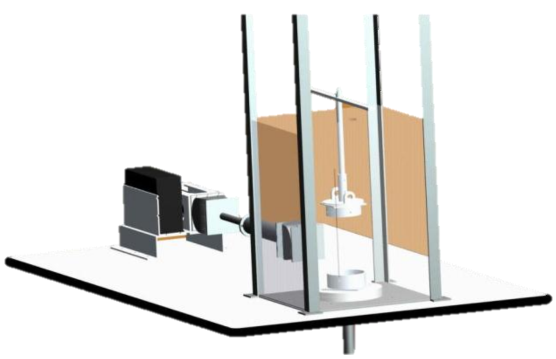
A.1.2. CAD Solid Model Assembly



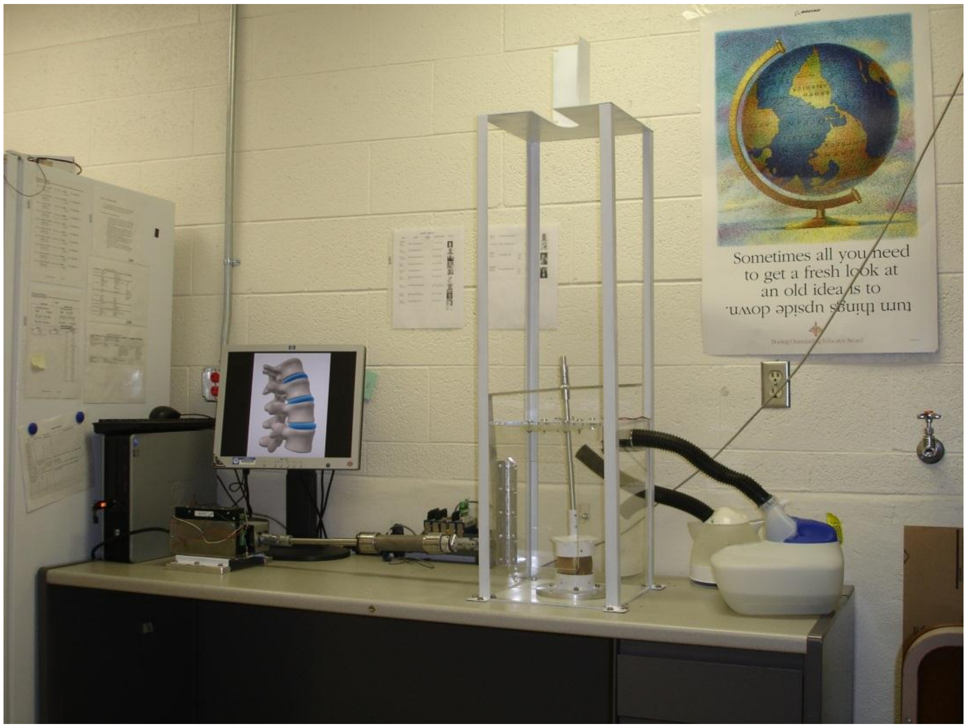








A.1.3 Physical Prototype



A.2. MASSUCE Software – LabView 2009 Project Files

The custom LabVIEW programs (extension ".vi") that control the MASSUCE and collect data are all contained in a single LabVIEW project file (extension ".lvproj"). This project file (MASSUCE_incremental.lvproj) has the functionality to perform biomechanical analysis using stepwise (SW, i.e. incremental) loading tests, as well as continuous-speed loading tests. The majority of the continuous-speed (CS) tests (those FSUs not included in the SW versus CS testing) were tested using a different LabVIEW project file (MASSUCE_continuous.lvproj); however the only difference between the two projects is in the fpga controller program (fpga_MASSUCE.vi). The fpga for "…incremental…" has an expanded "Torque & Position Controller", whereas "…continuous…" has a more simplified controller. The two different controllers

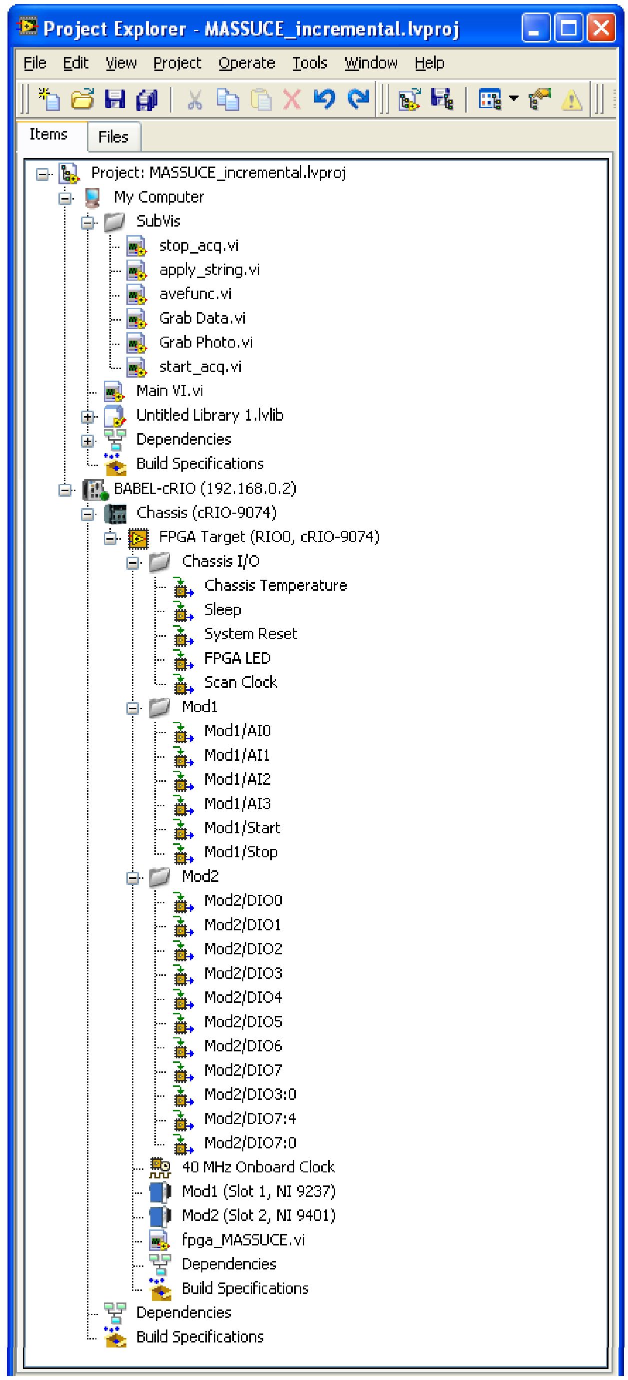


Figure A-1: Project Explorer window of the "MASSUCE_incremental.lvproj" project file.

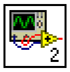
were necessary because the (smaller, simpler) controller in "…continuous …" compiled significantly faster and ran more smoothly.

All programs are called by the program "Main VI.vi", and are listed as "SubVIs" in the project explorer window (). The FPGA program (fpga_MASSUCE.vi) is installed and run on the communicating LabVIEW hardware, which consists of an external FPGA-driven, real-time module (cRIO-9074) that communicates with the computer via the Ethernet port.

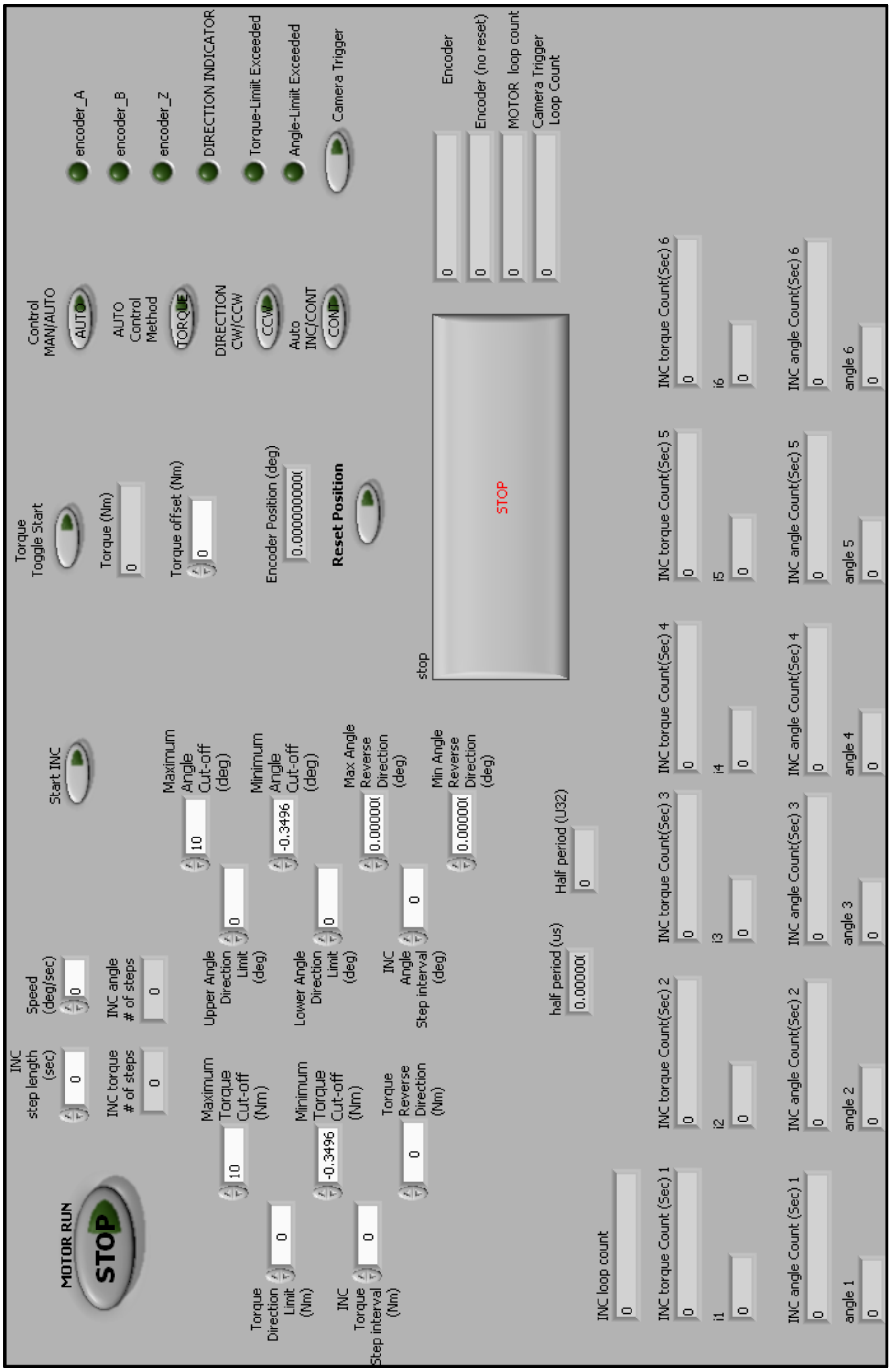
Documentation is provided below for all the VIs called in this project. They are below as follows:

- A.2.1 fpga_MASSUCE.vi
- A.2.2 Main VI.vi
- A.2.3 apply_string.vi
- A.2.4 avefunc.vi
- A.2.5 Grab Data.vi
- A.2.6 Grab Photo.vi
- A.2.7 start_acq.vi
- A.2.8 stop_acq.vi

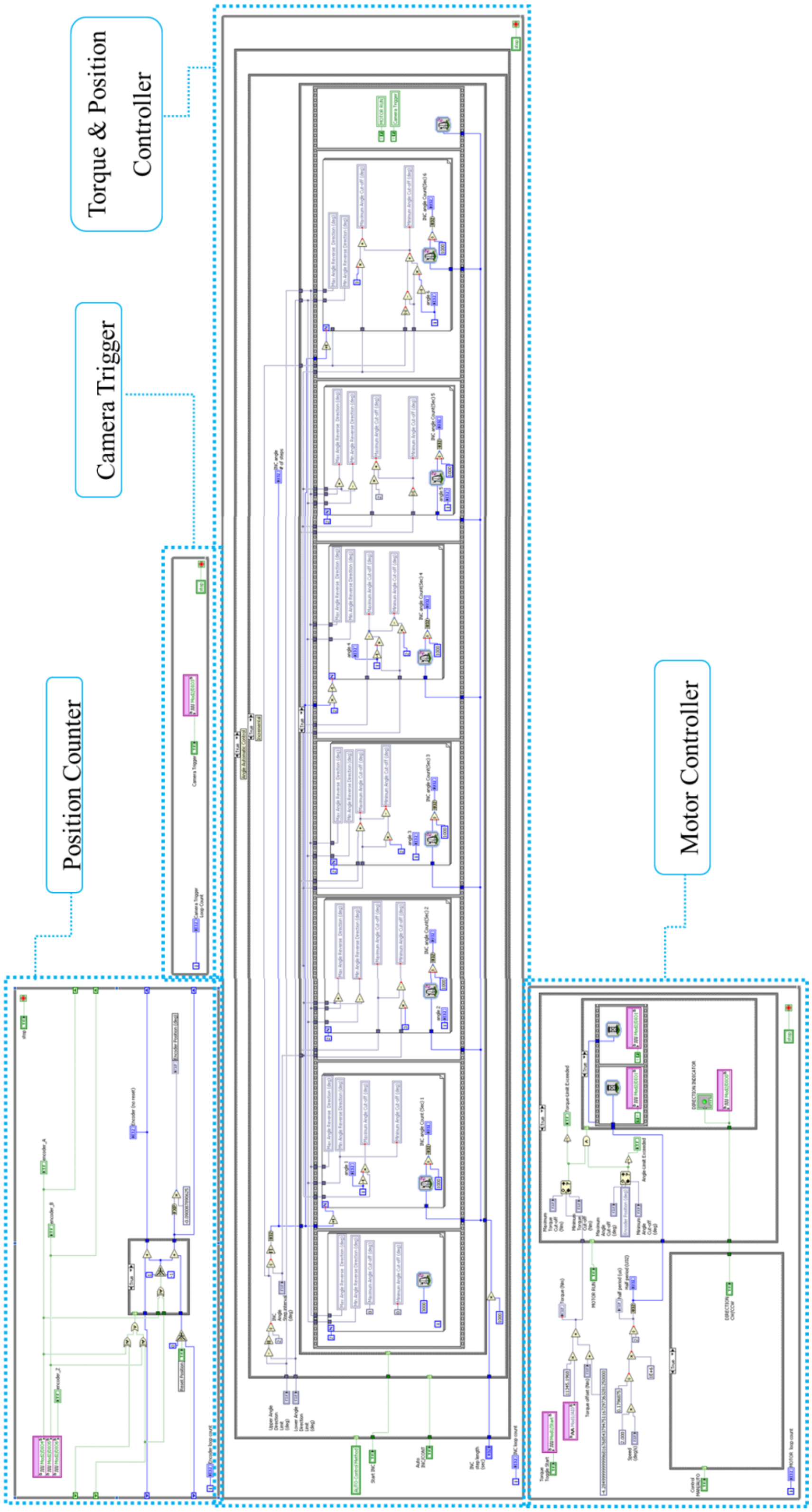
A.2.1. fpga_MASSUCE.vi



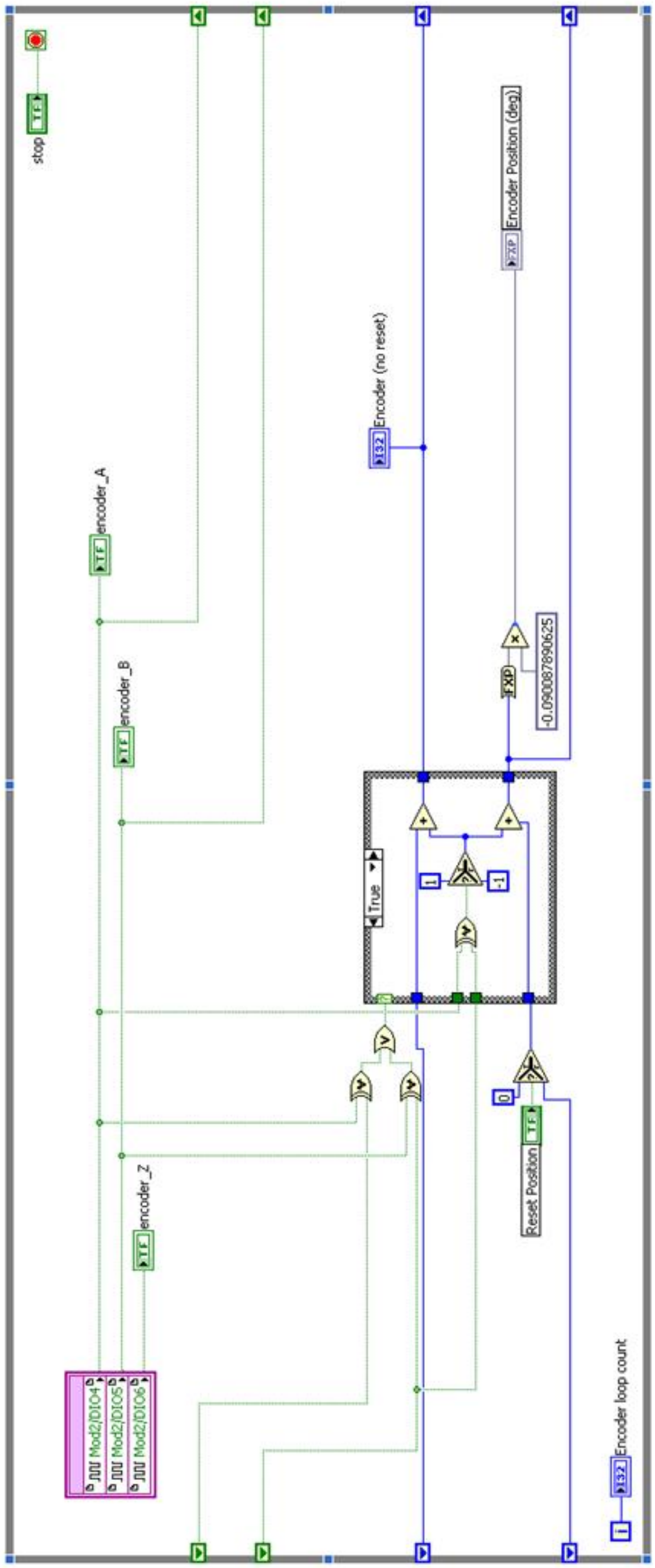
FRONT PANEL (fpga_MASSUCE.vi)

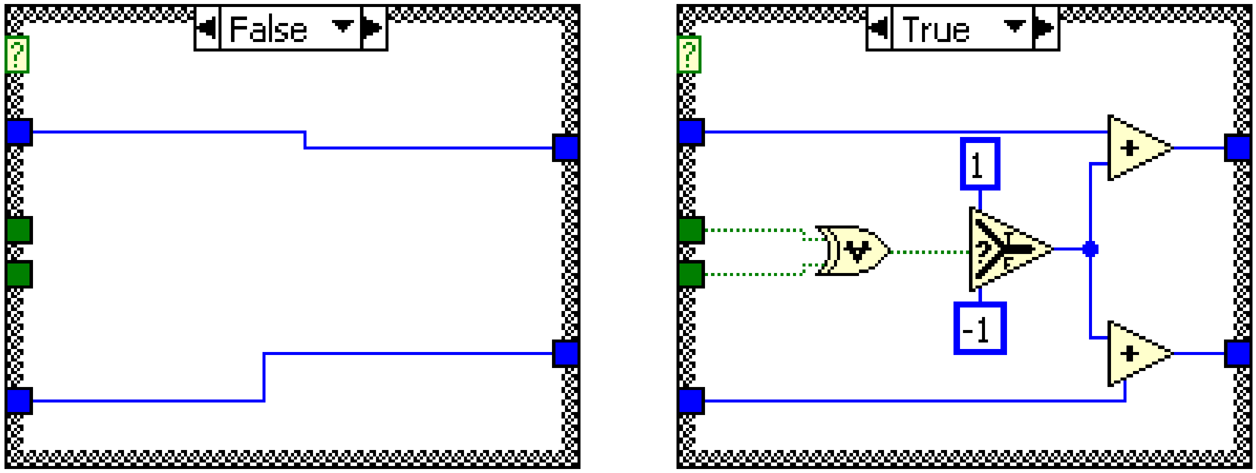


BLOCK DIAGRAM (fpga_MASSUCE.vi)

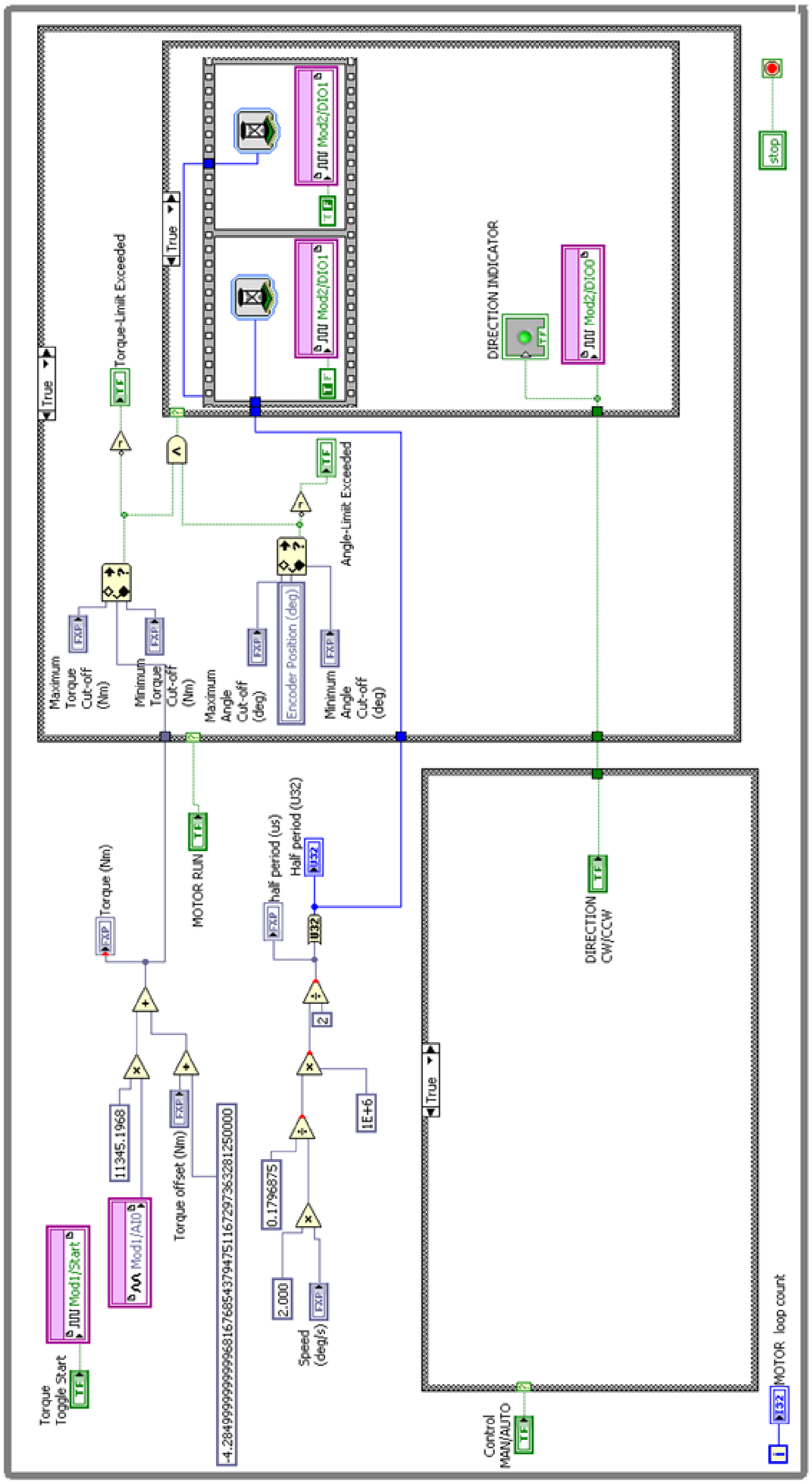


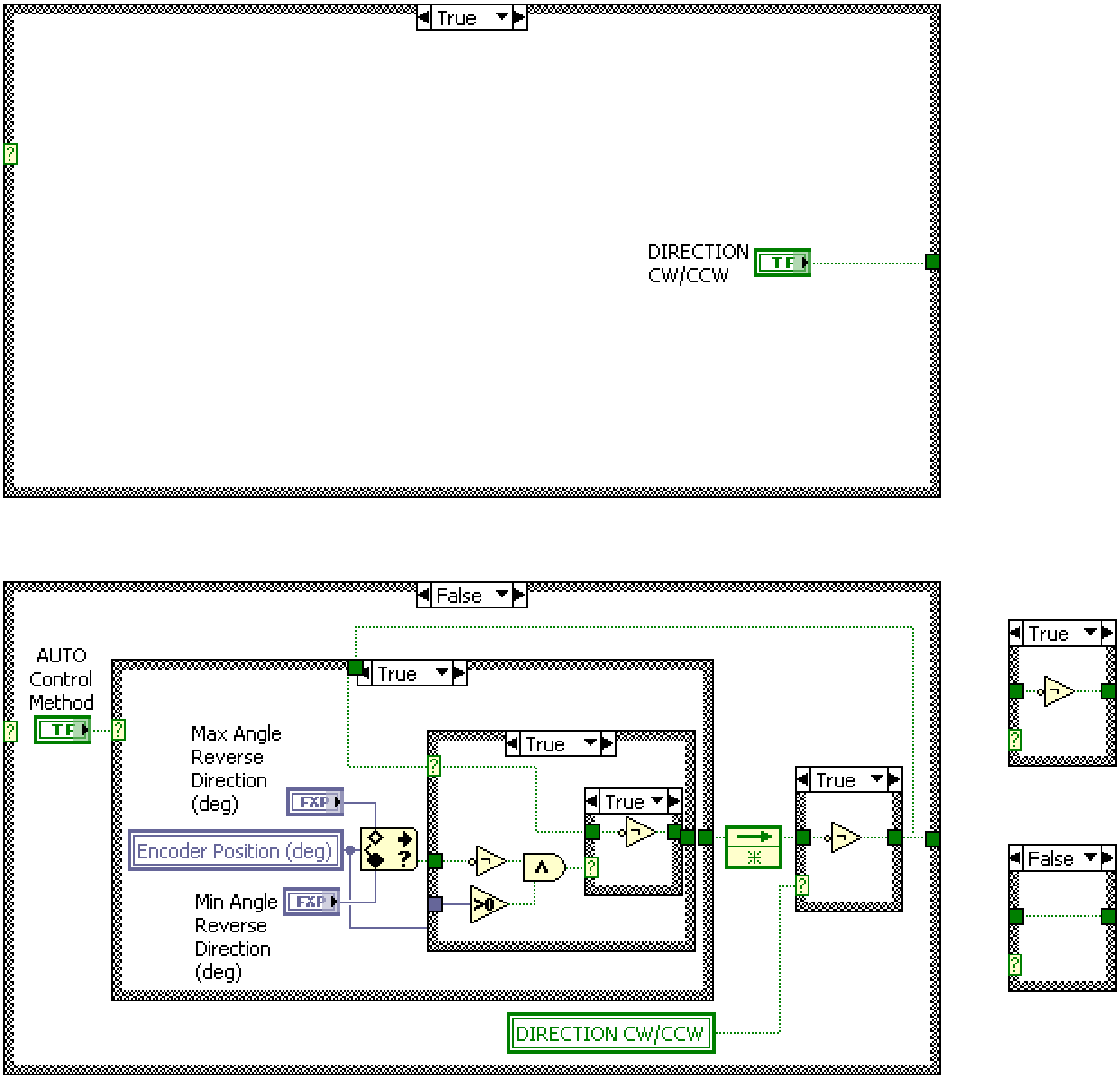
Position Counter

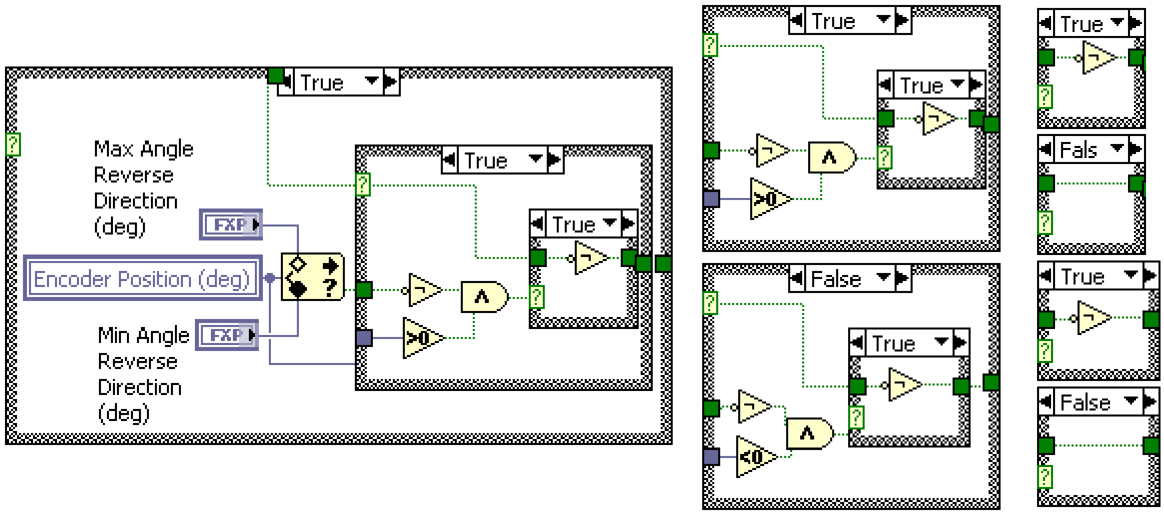


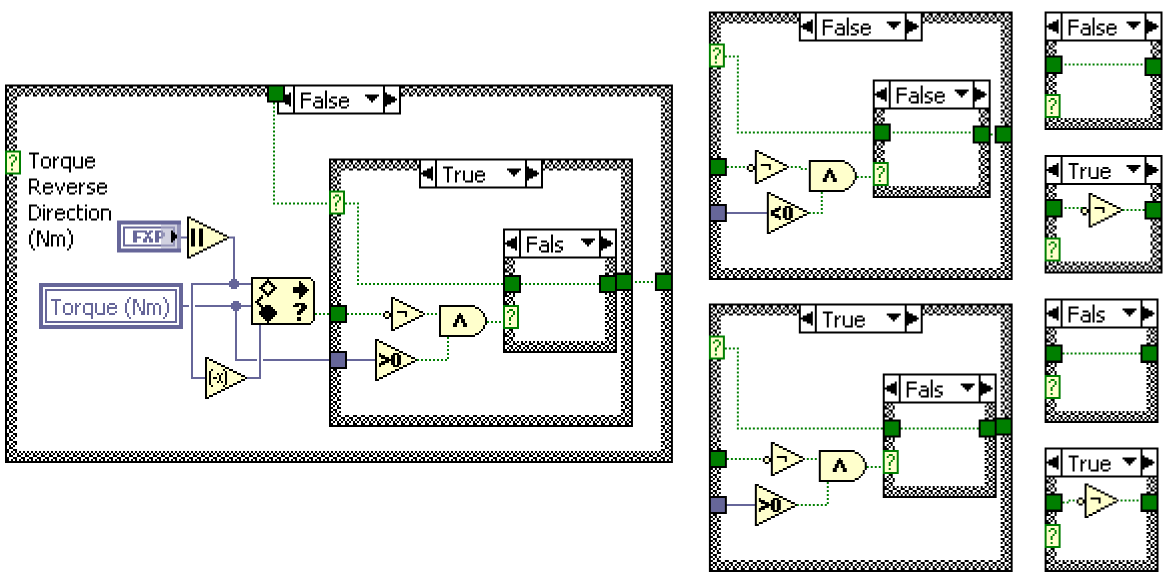

False
True
1
-1

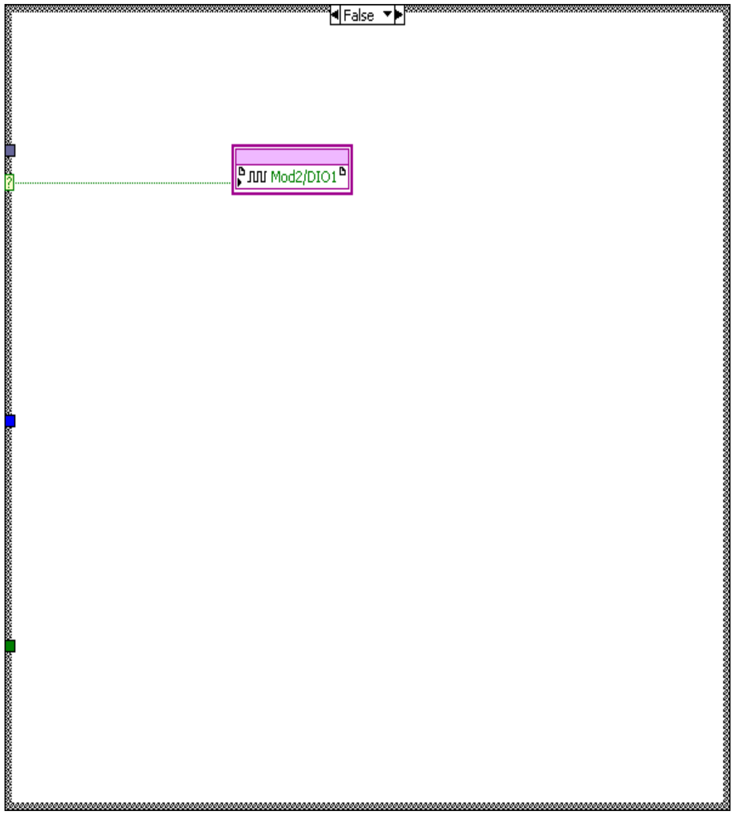
Motor Controller (fpga_MASSUCE.vi)

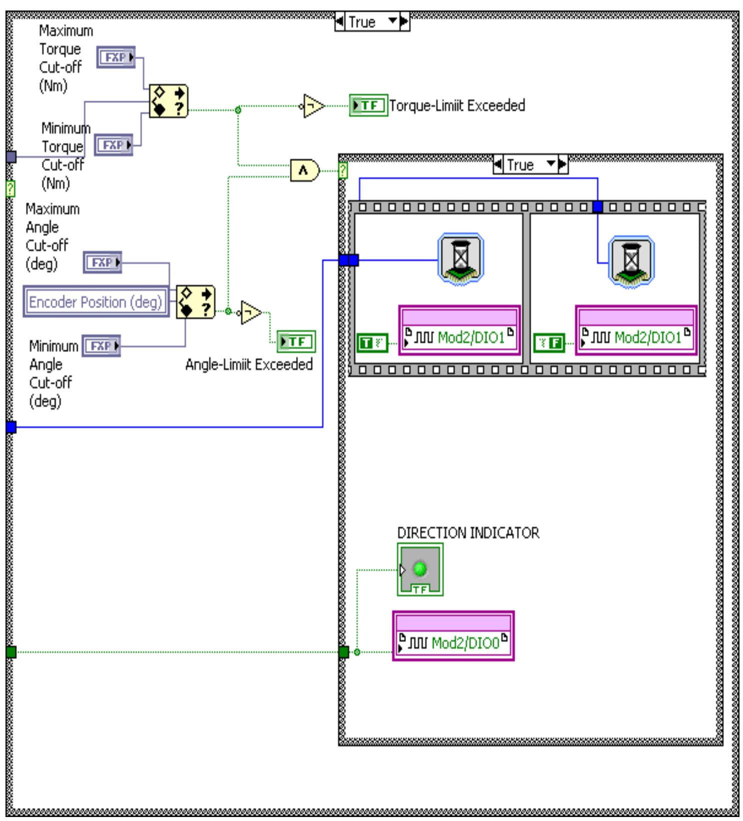


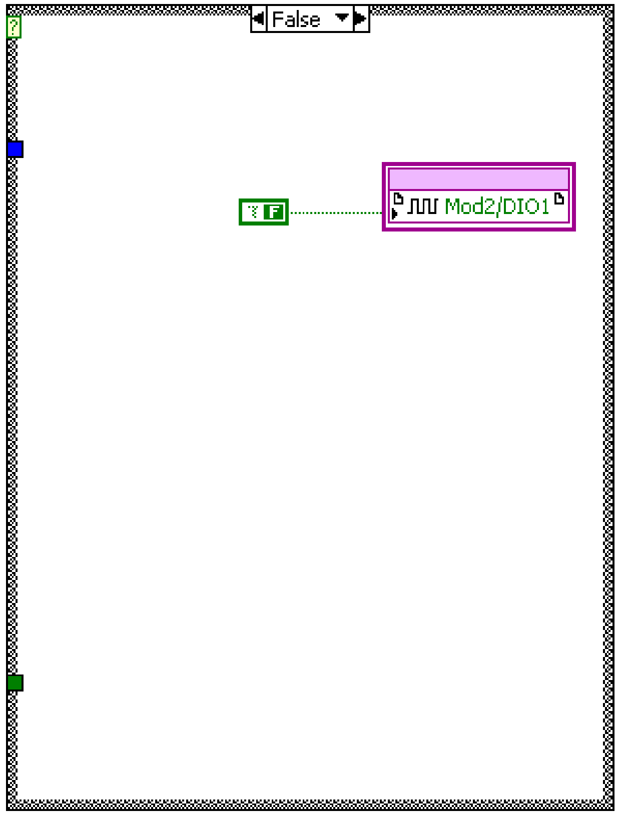

True
DIRECTION CW/CCW
False
AUTO Control Method
True
Max Angle Reverse Direction (deg)
Encoder Position (deg)
Min Angle Reverse Direction (deg)
True
True
True
DIRECTION CW/CCW
True
False

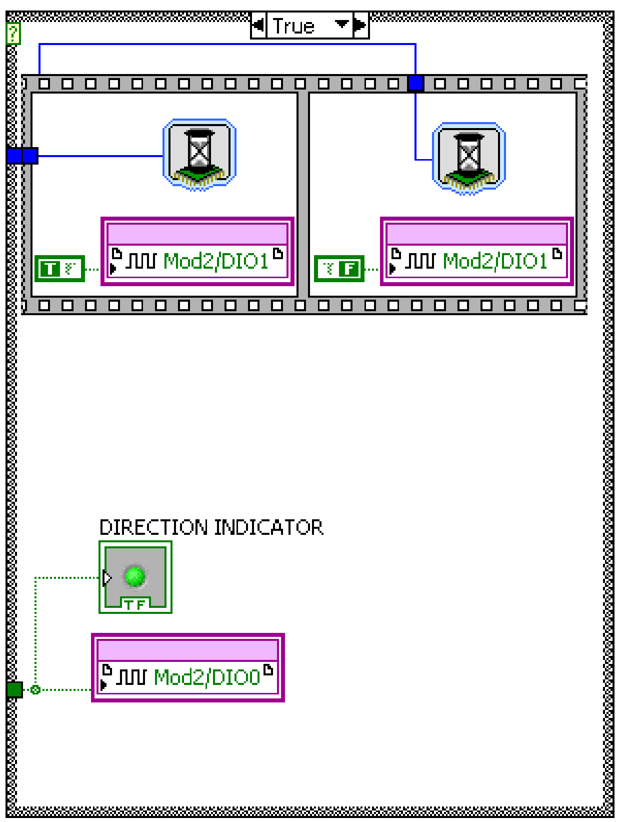

True
Max Angle
Reverse
Direction
(deg)
FXP
Encoder Position (deg)
Min Angle
Reverse
Direction
(deg)
False
Fals
>0
<0


False
Torque
Reverse
Direction
(Nm)
FXP
Torque (Nm)
True
Fals
>0
<0

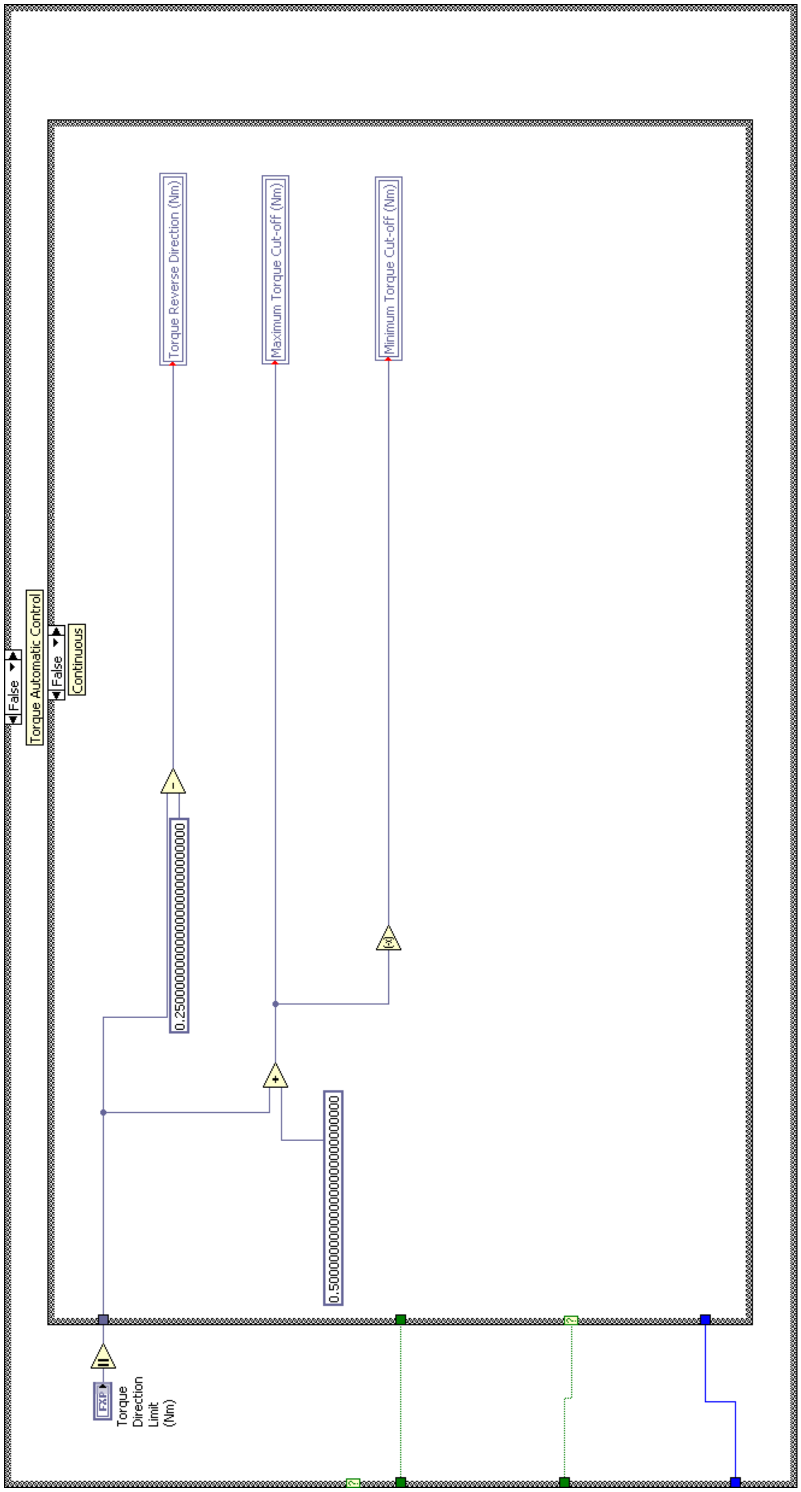

False
Mod2/DIO1

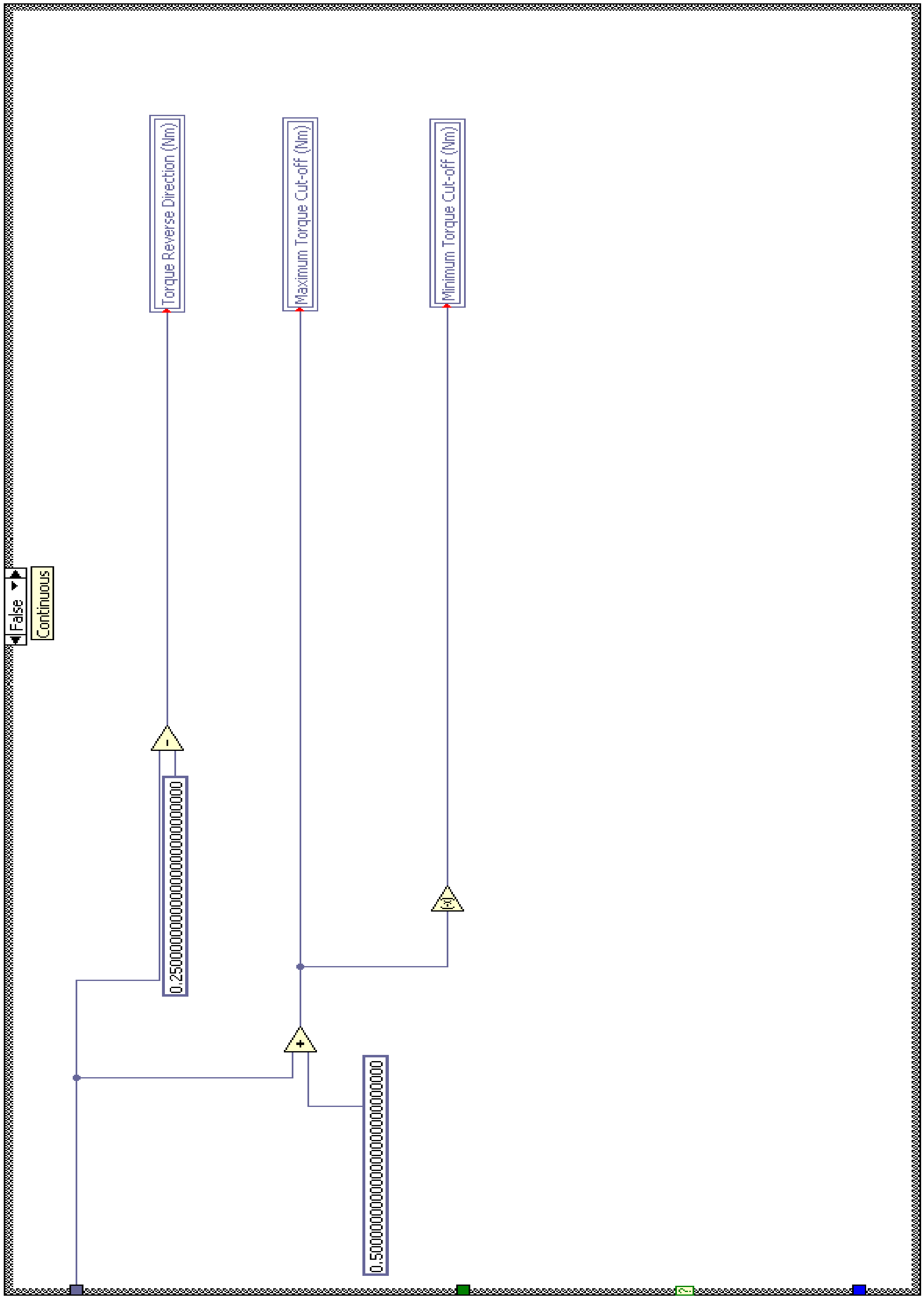

True
Maximum Torque Cut-off (Nm)
Minimum Torque Cut-off (Nm)
Torque-Limiit Exceeded
Maximum Angle Cut-off (deg)
Encoder Position (deg)
Minimum Angle Cut-off (deg)
Angle-Limiit Exceeded
True
Mod2/DIO1
Mod2/DIO1
DIRECTION INDICATOR
Mod2/DIO0

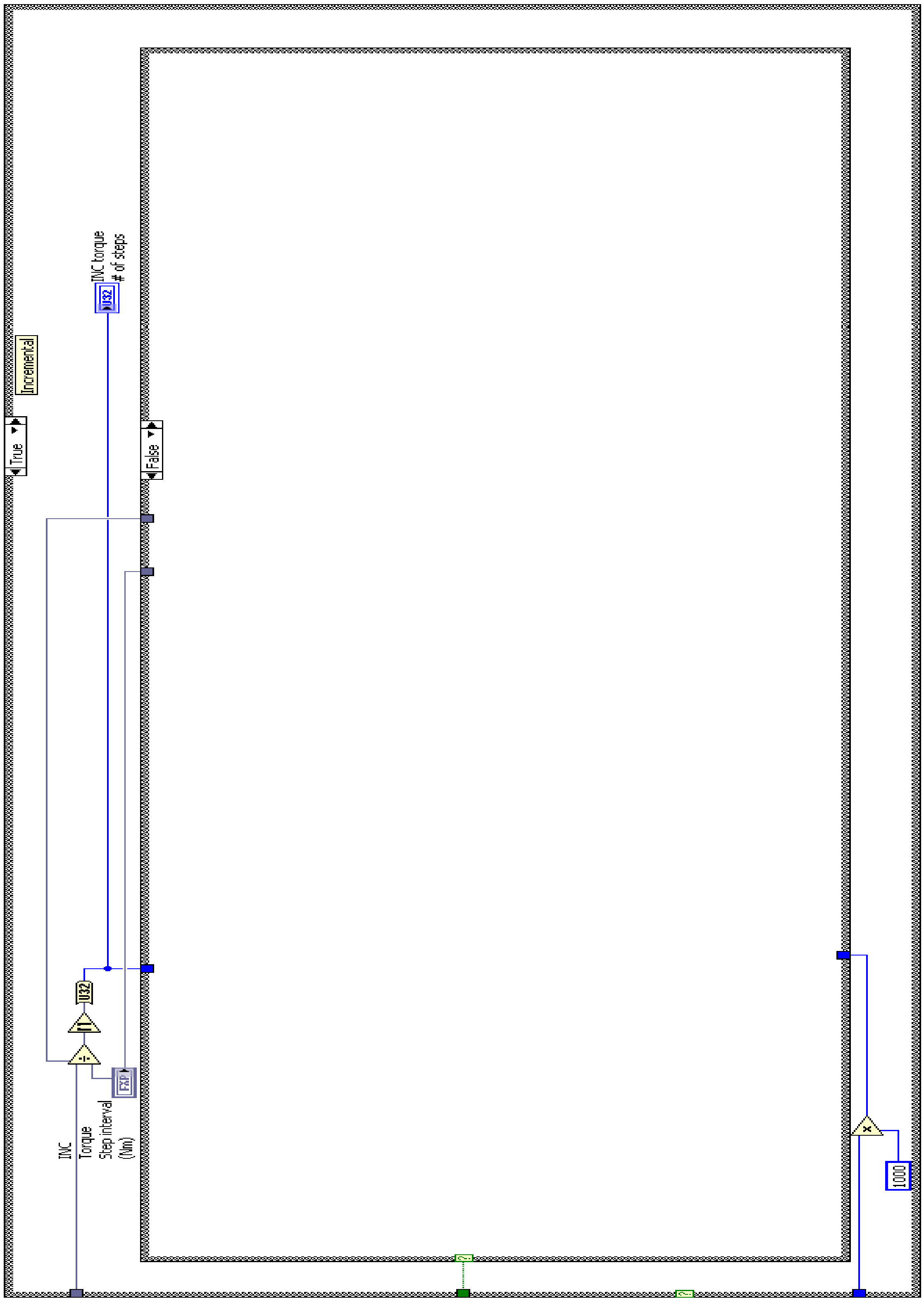

False
Mod2/DIO1

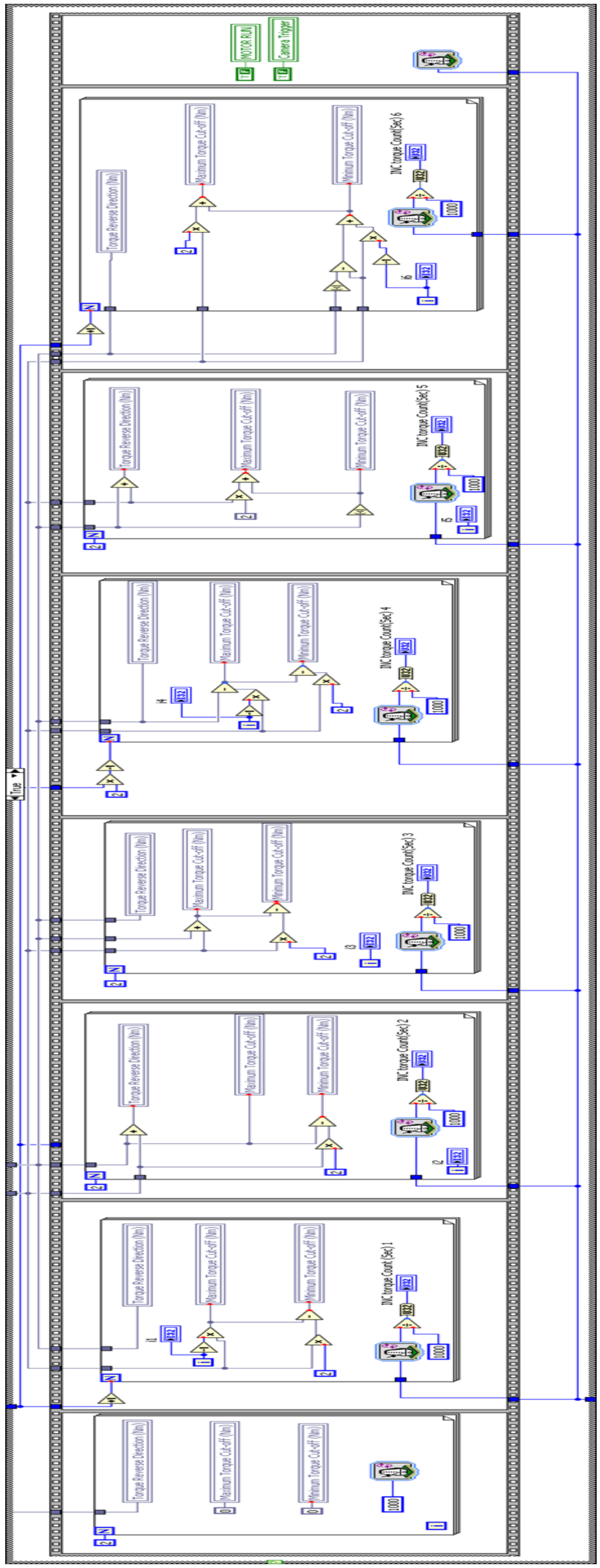

True
Mod2/DIO1
Mod2/DIO1
DIRECTION INDICATOR
Mod2/DIO0

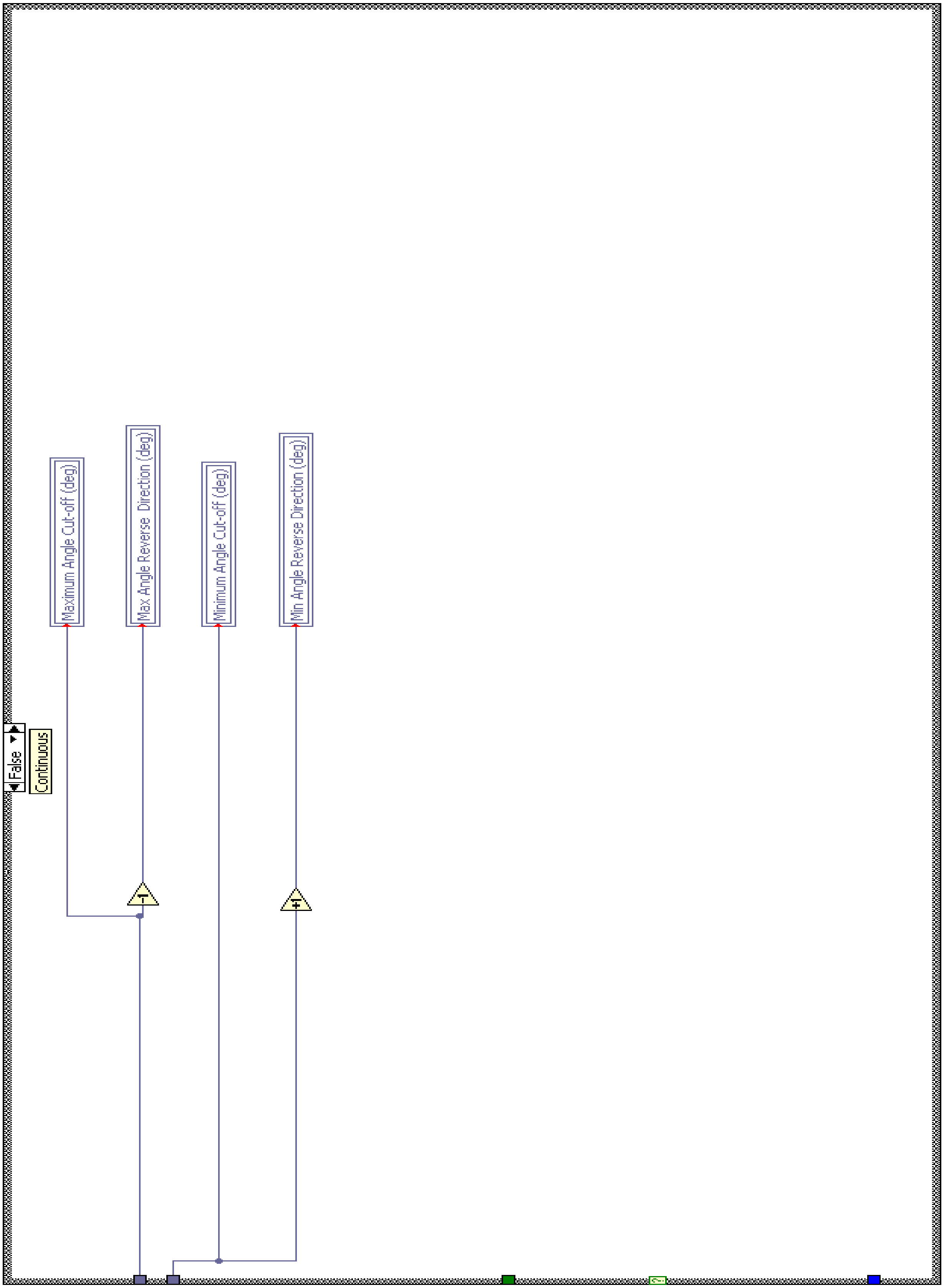
Torque & Position Controller (fpga_MASSUCE.vi)

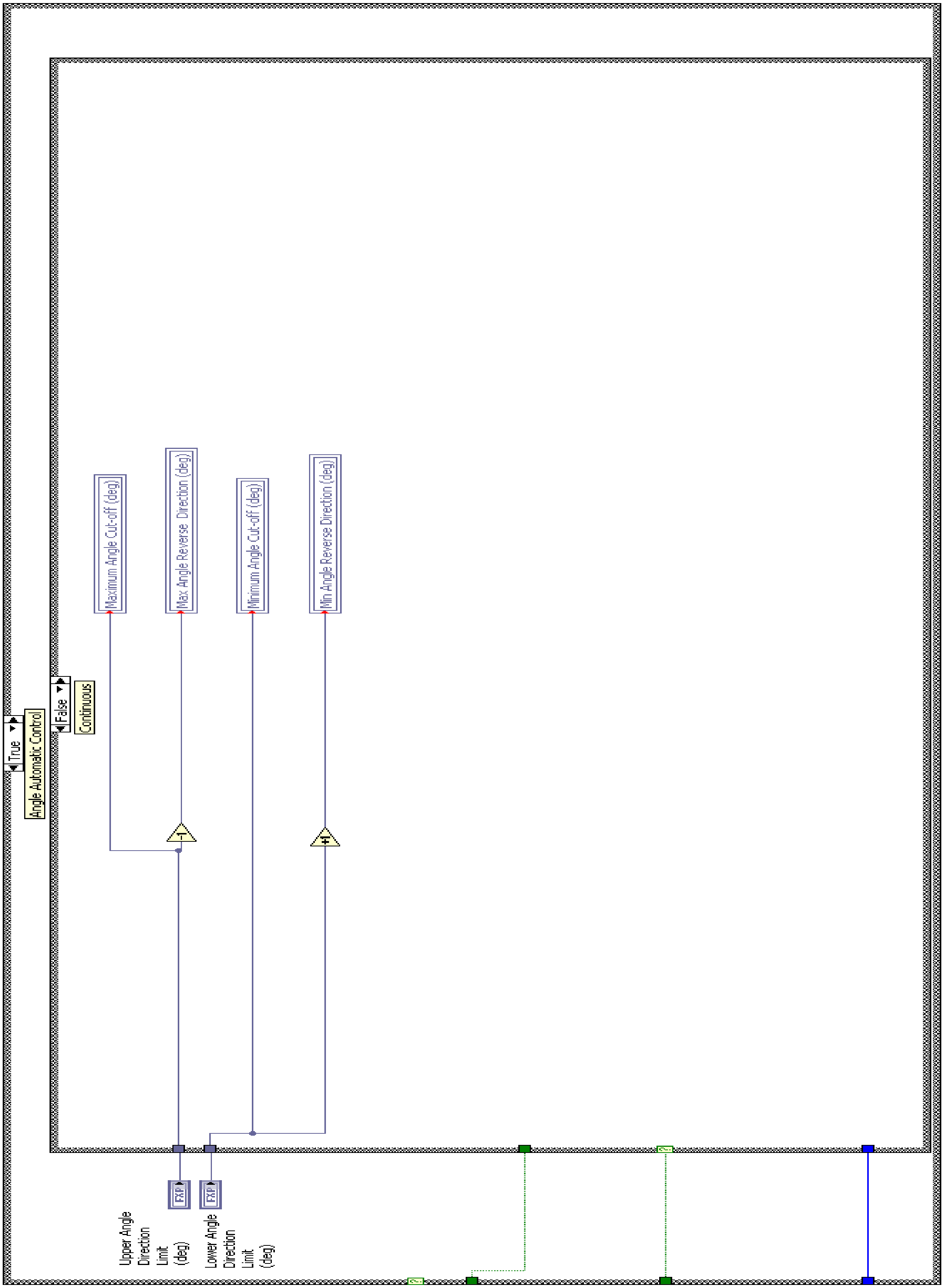


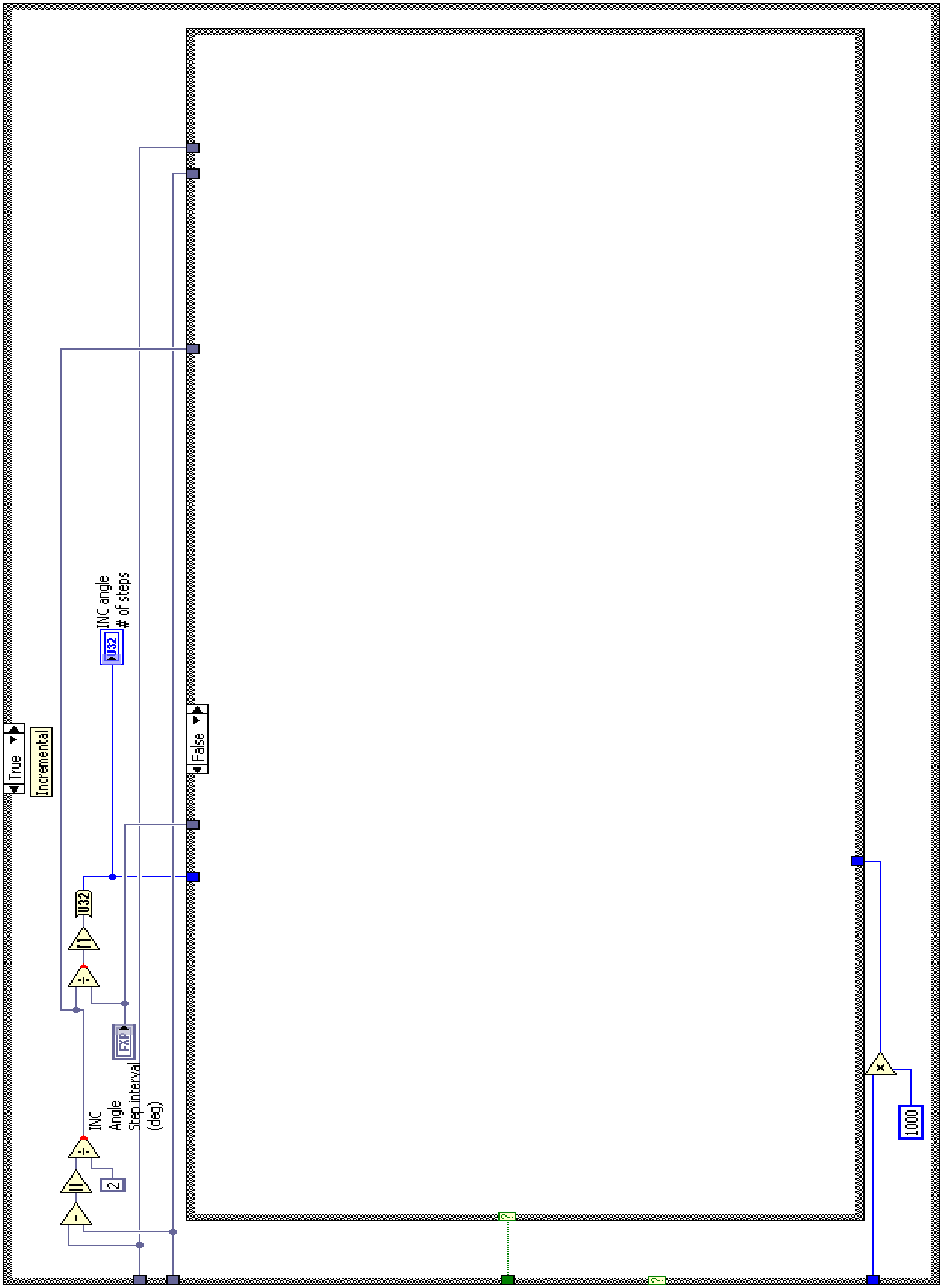

Torque Reverse Direction (Nm)
Maximum Torque Cut-off (Nm)
Minimum Torque Cut-off (Nm)
False
Continuous
0.250000000000000000000000
0.500000000000000000000000

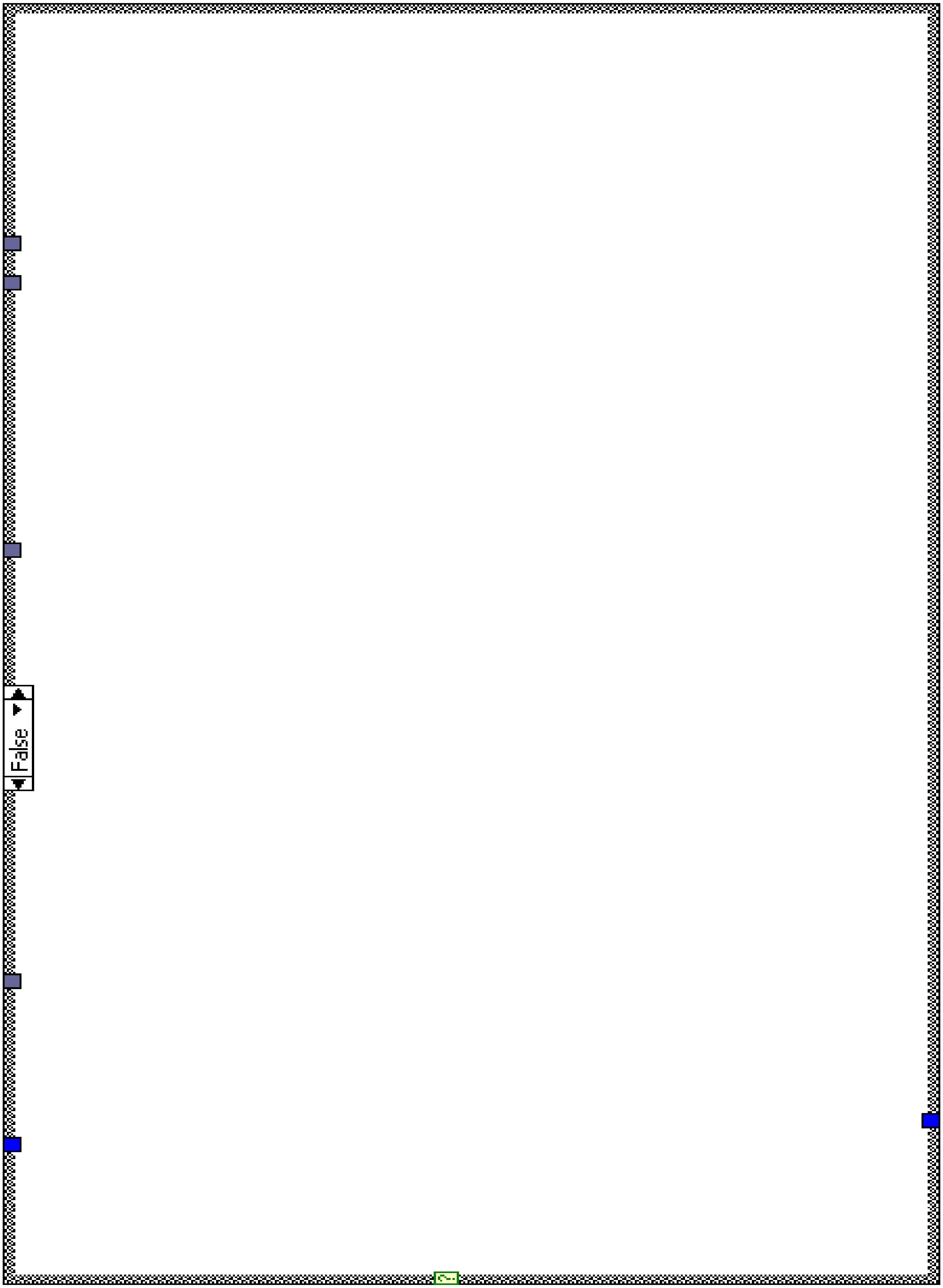

Incremental
True
False
INC torque
# of steps
U32
INC
Torque
Step interval
(Nm)
EXT
1000

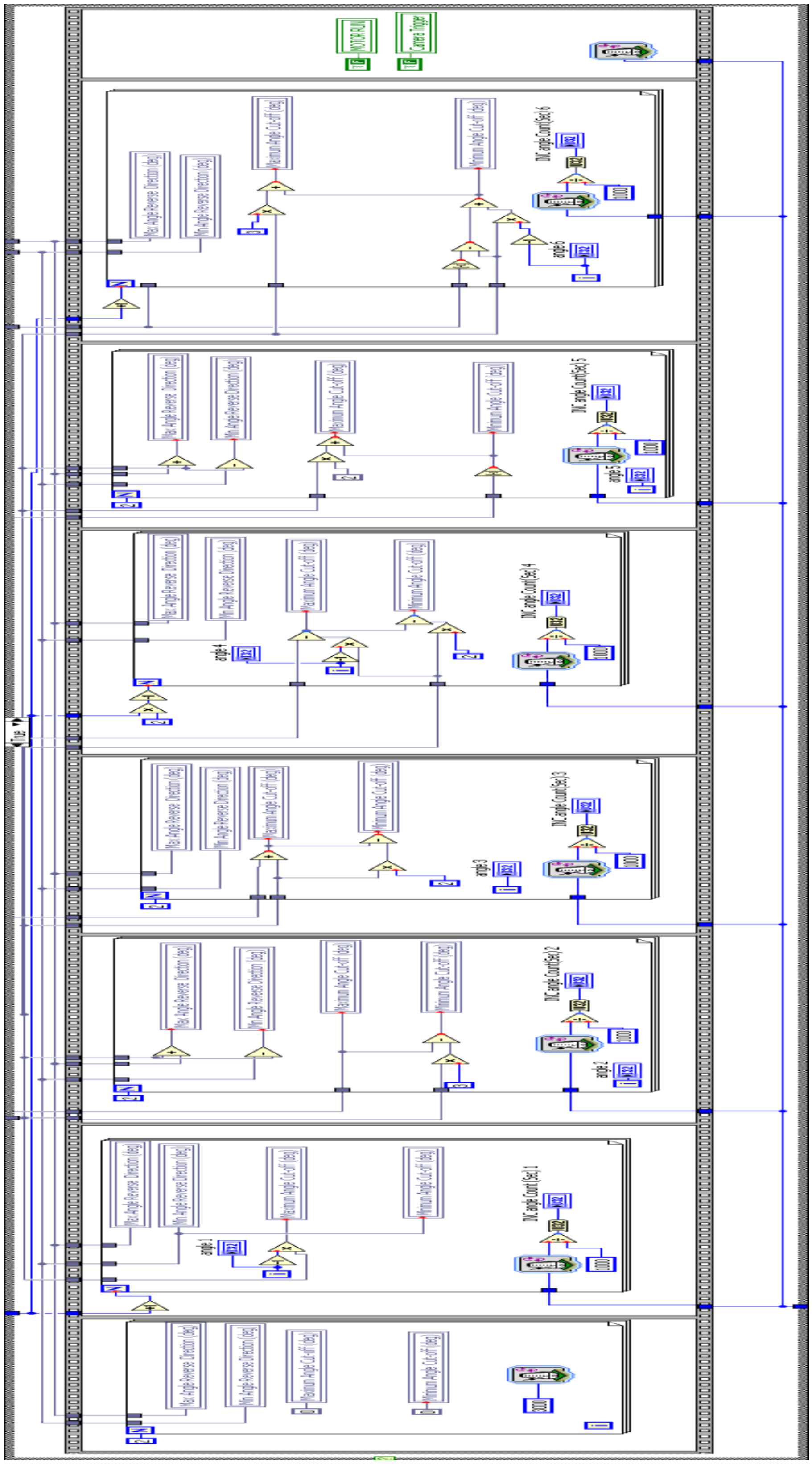

MOTOR RUN
Camera Trigger
Torque Reverse Direction (Nm)
Maximum Torque Cut-off (Nm)
Minimum Torque Cut-off (Nm)


False
Continuous
Maximum Angle Cut-off (deg)
Max Angle Reverse Direction (deg)
Minimum Angle Cut-off (deg)
Min Angle Reverse Direction (deg)
-1
+1


True
Angle Automatic Control
False
Continuous
Maximum Angle Cut-off (deg)
Max Angle Reverse Direction (deg)
Minimum Angle Cut-off (deg)
Min Angle Reverse Direction (deg)
-1
+1
EXP
EXP
Upper Angle Direction Limit (deg)
Lower Angle Direction Limit (deg)


True
Incremental
INC angle
# of steps
U32
False
INC
Angle
Step interval
(deg)
FXP
2
1000

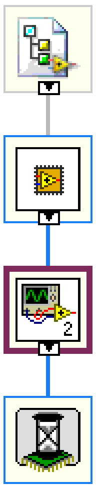

False



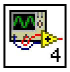
"fpga_MASSUCE.vi History"

Current Revision: 173

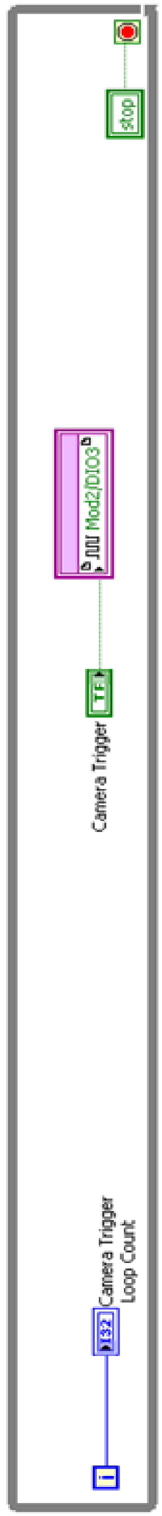
Position in Hierarchy



Main VI.vi

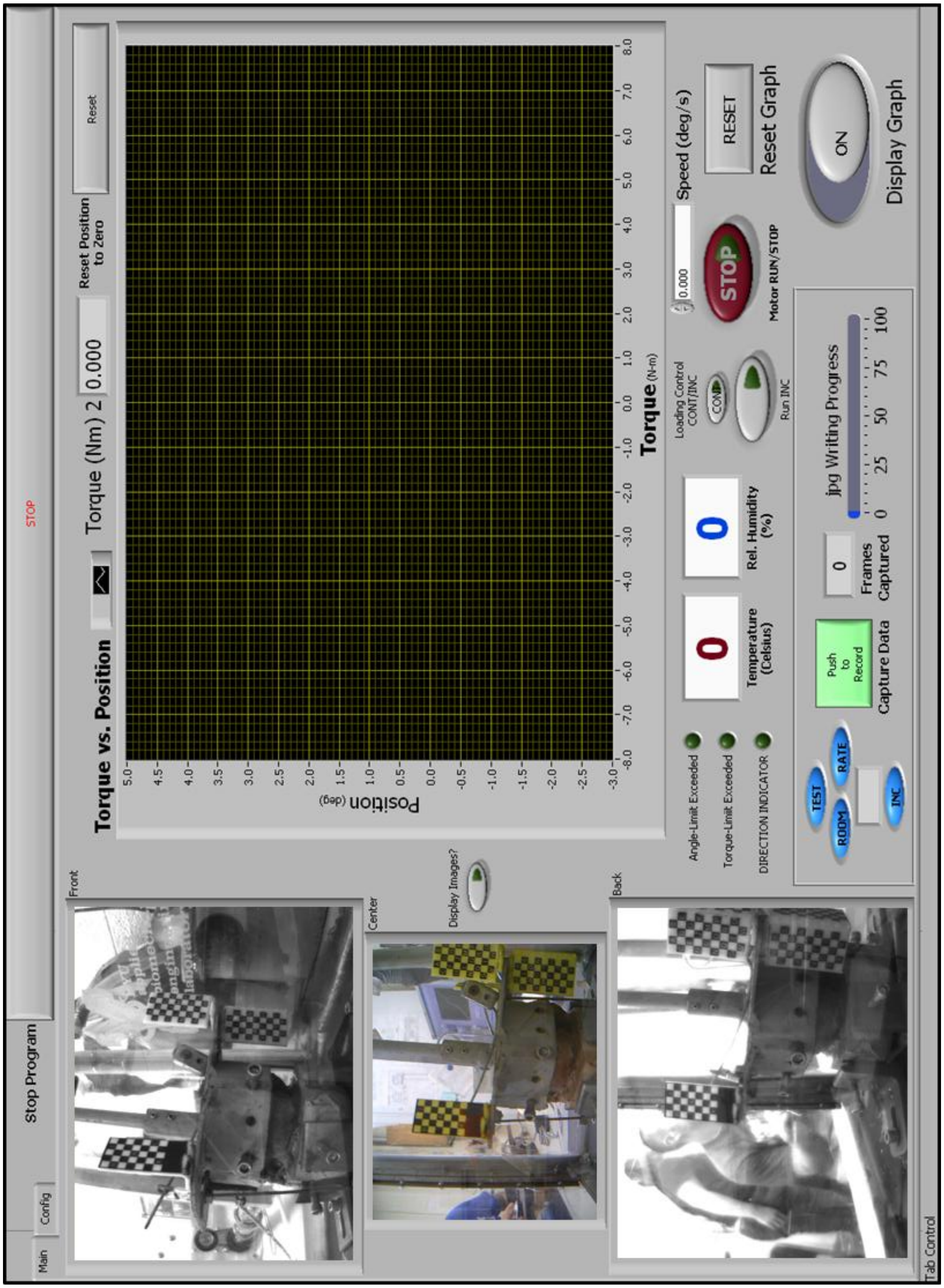


Camera Trigger (fpga_MASSUCE.vi)

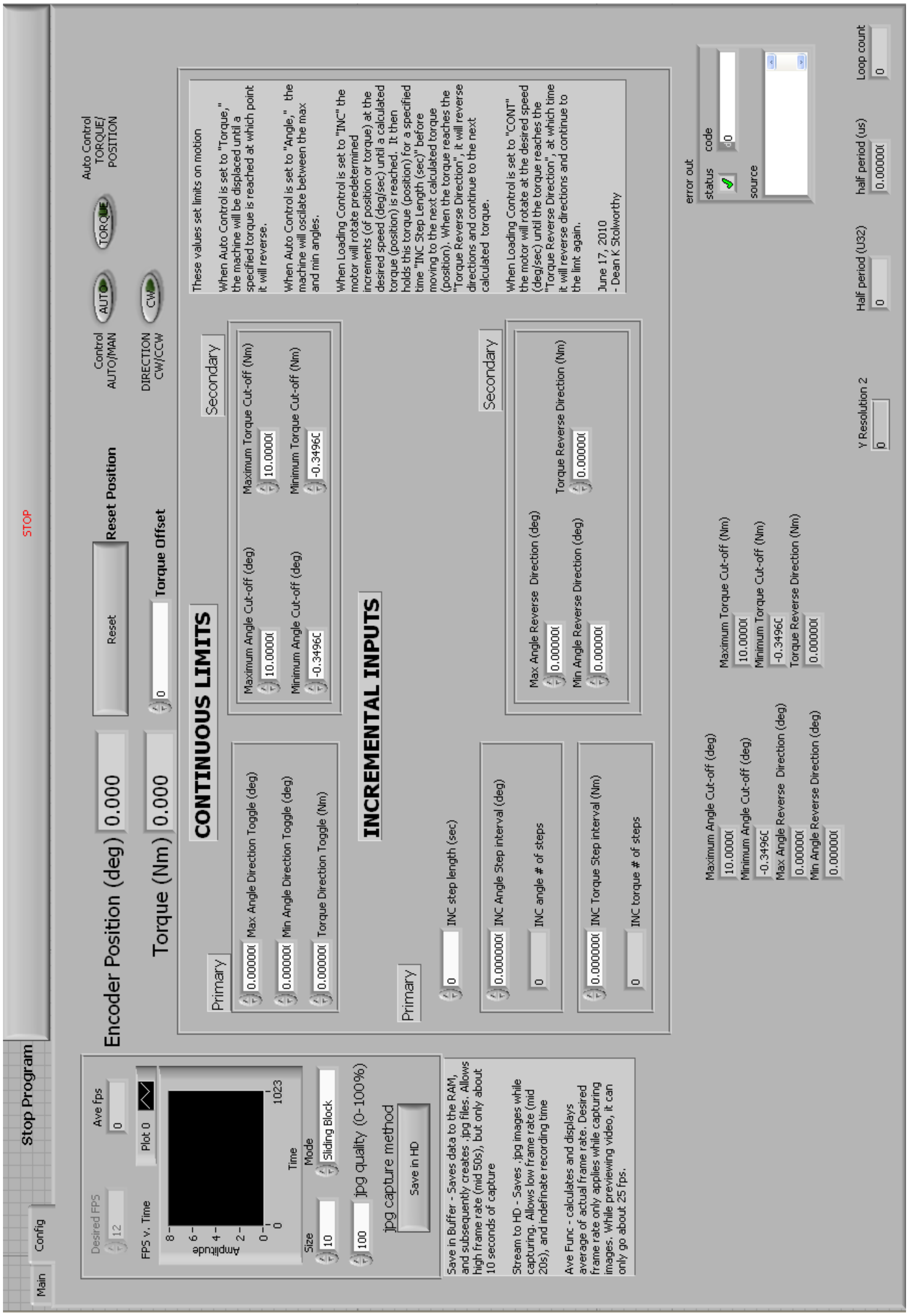


A.2.2. Main VI.vi

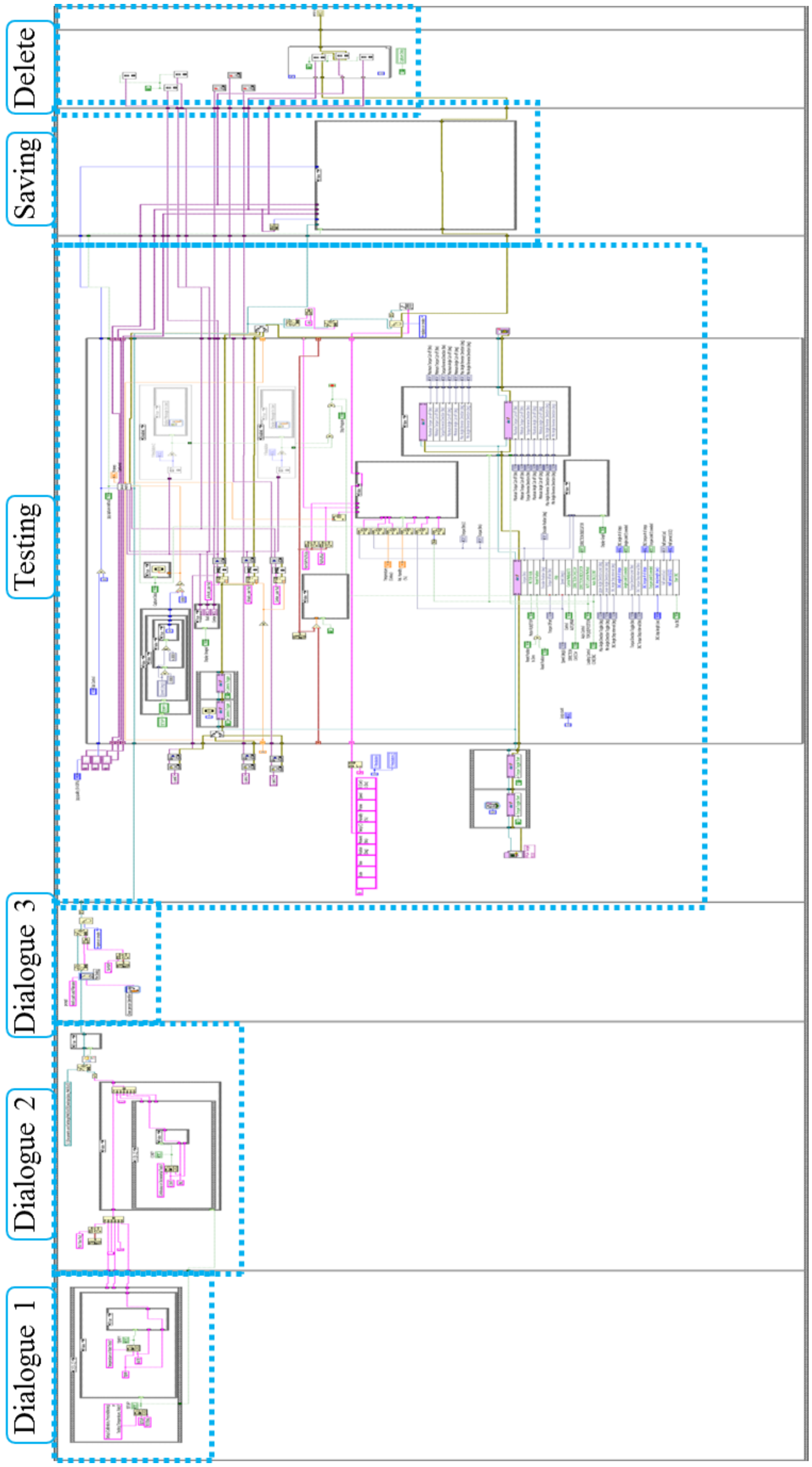
FRONT PANEL- Main Tab (Main.vi)



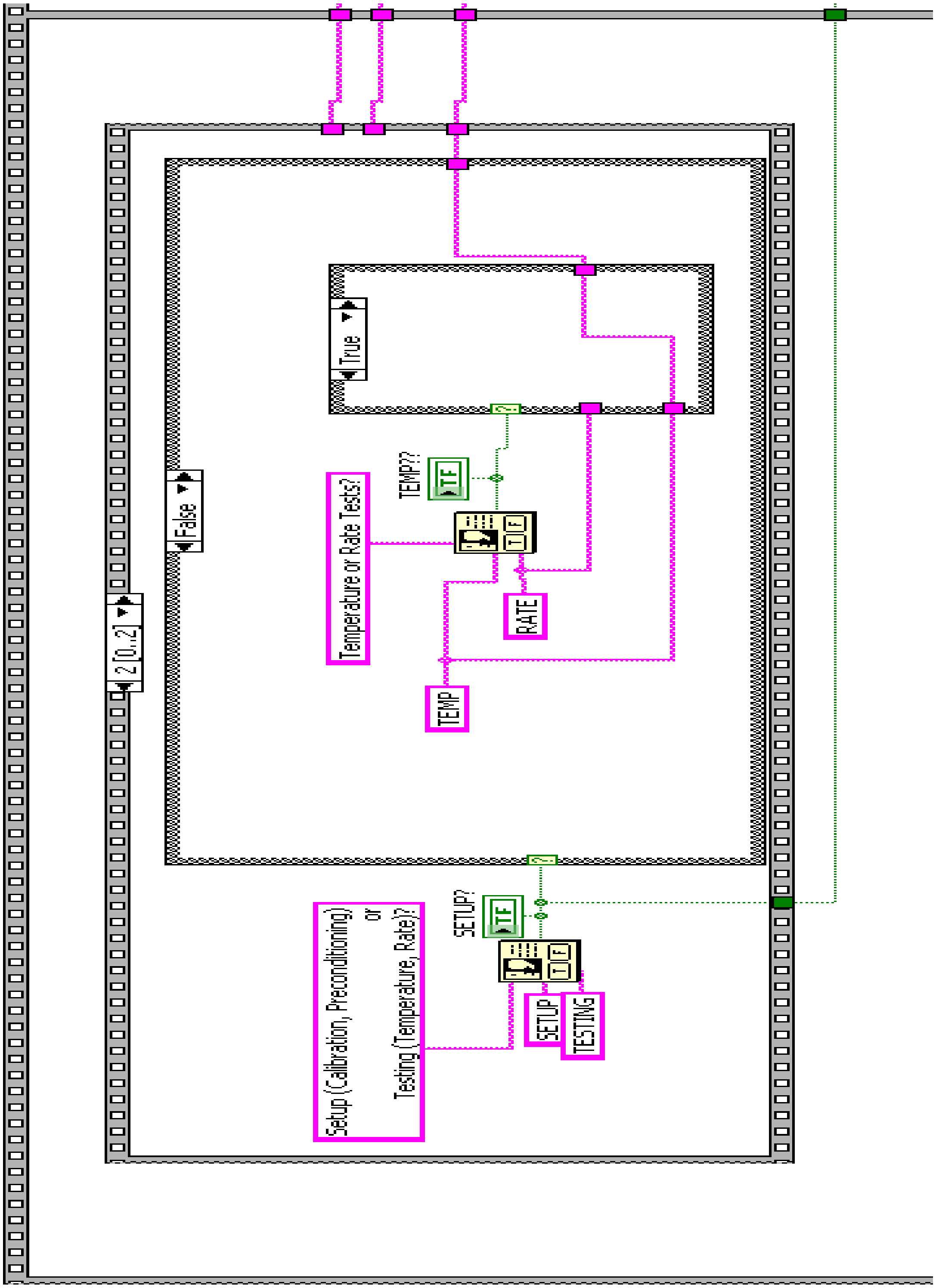
FRONT PANEL- Config Tab (Main.vi)

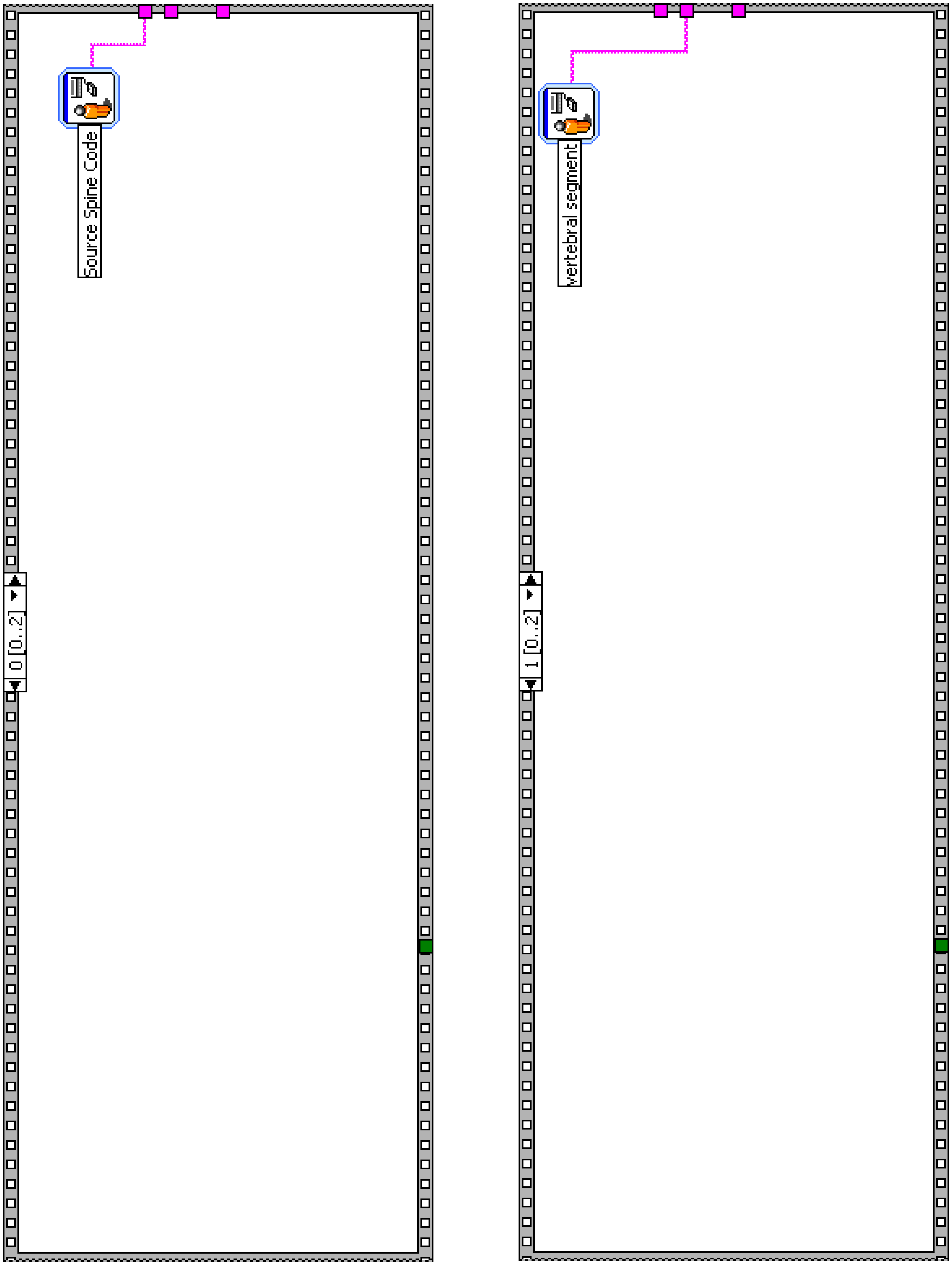


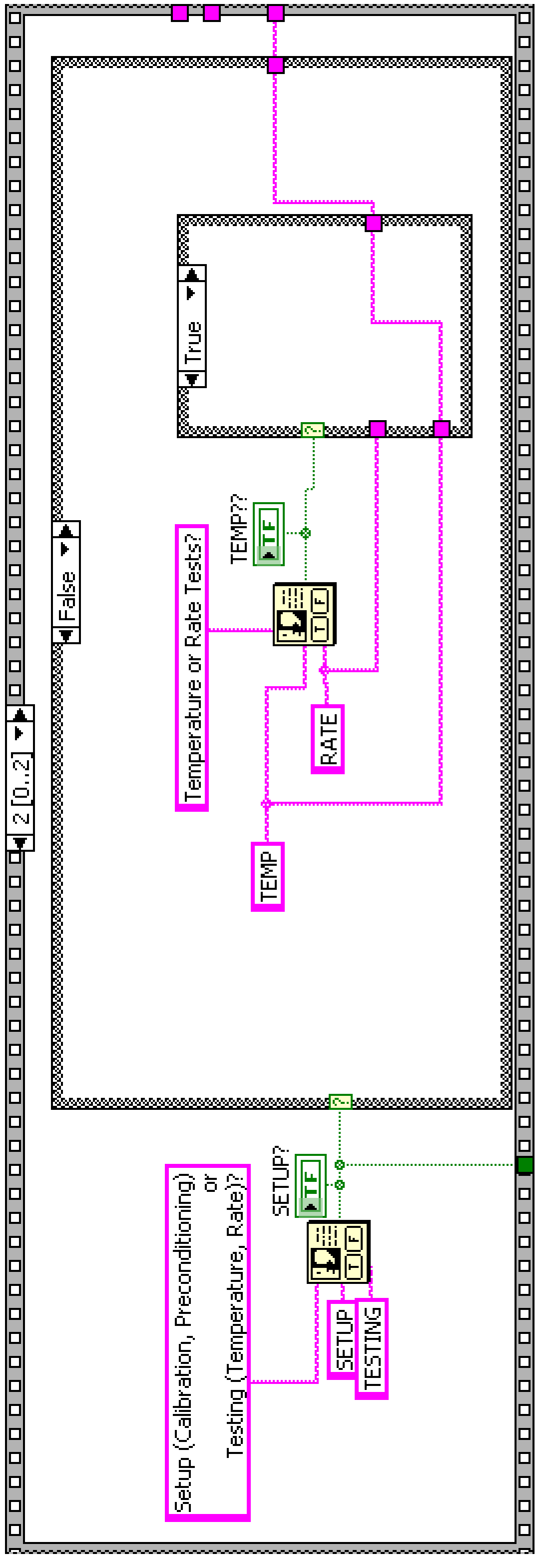
BLOCK PANEL (Main.vi)

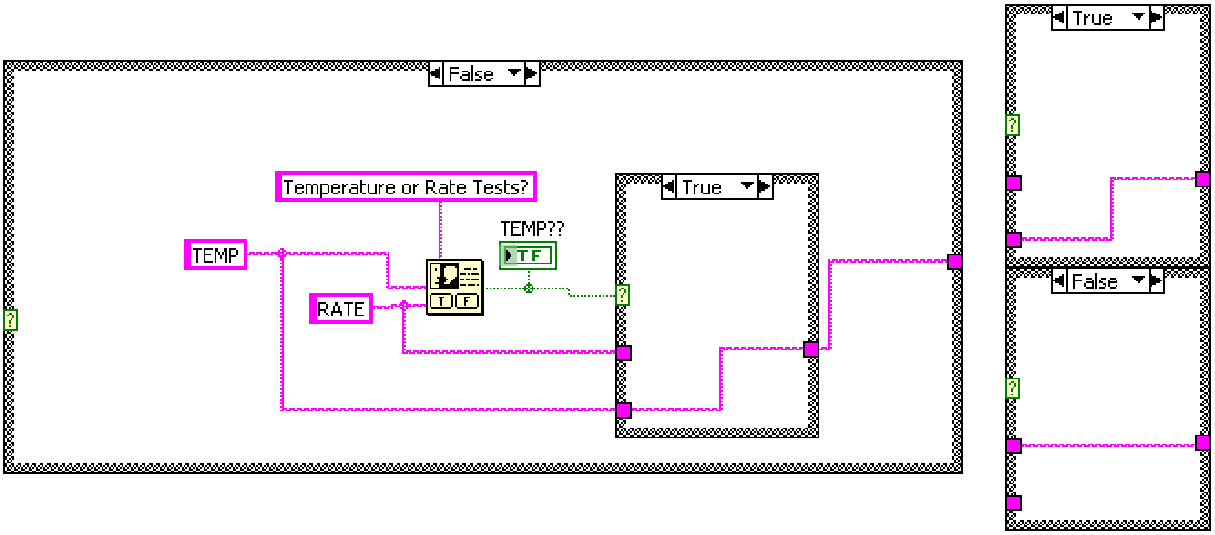


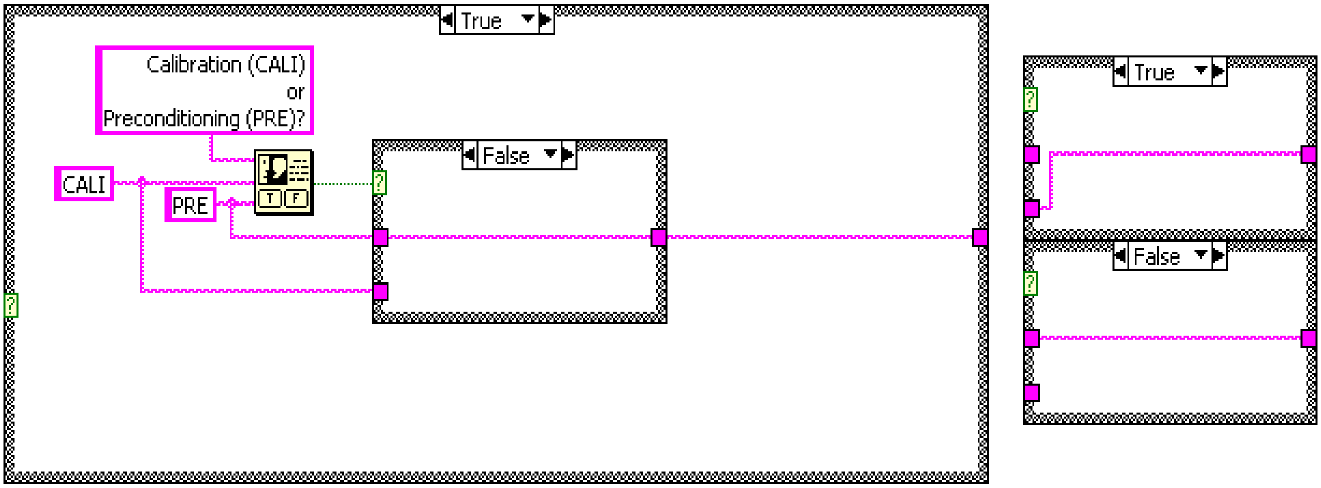
BLOCK PANEL (Main.vi) - Dialogue 1



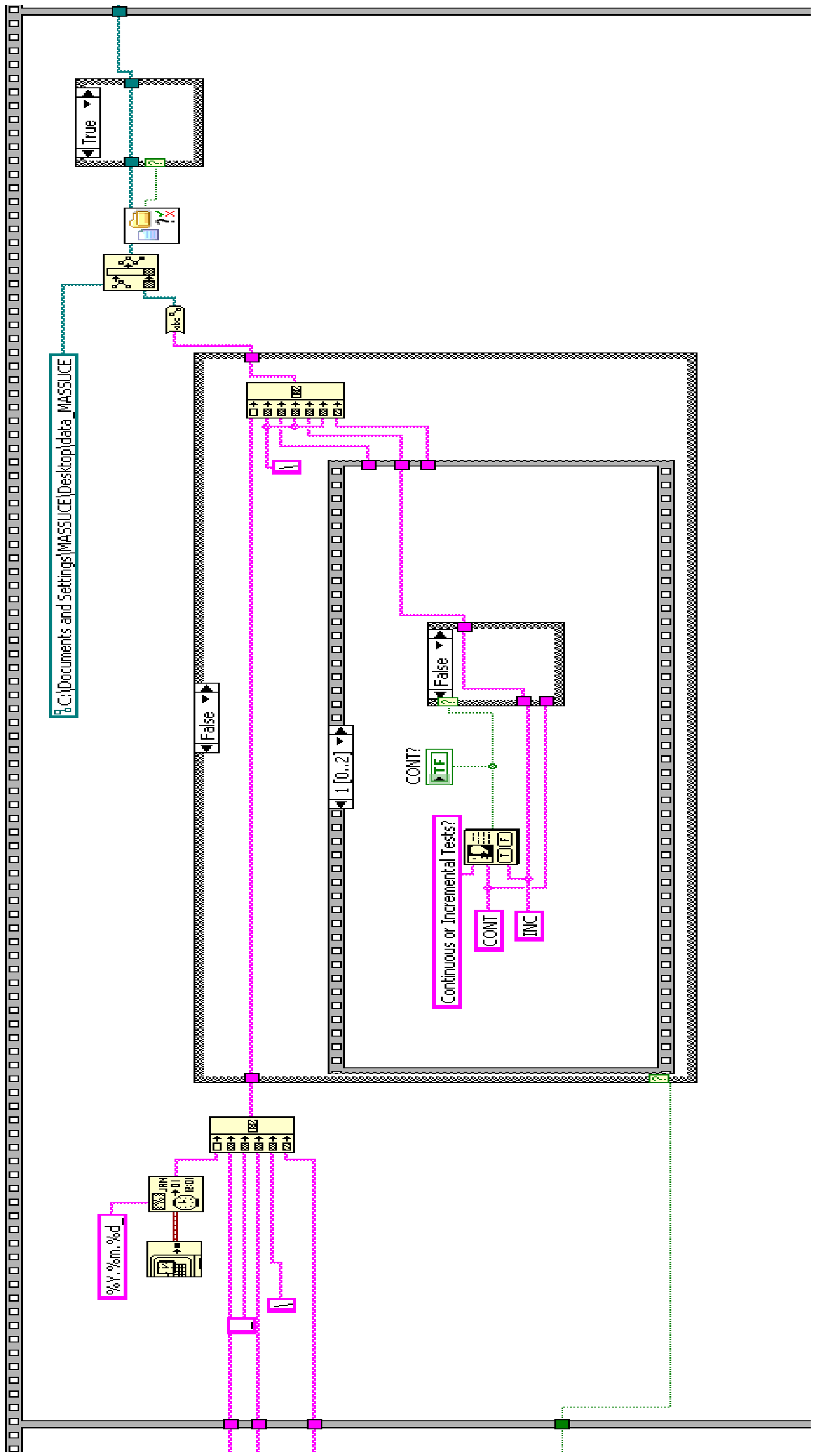

Source Spine Code
0 [0..2]
vertebral segment
1 [0..2]

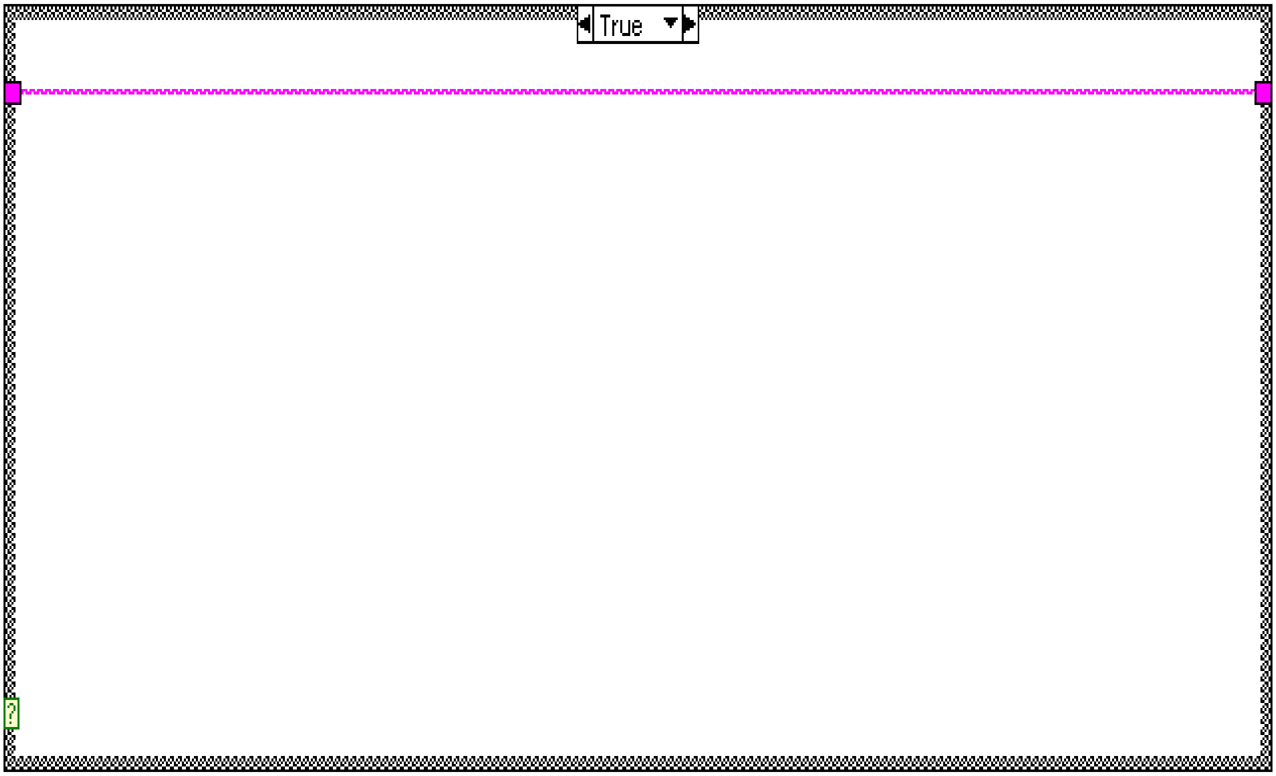

2 [0..2]
False
True
Temperature or Rate Tests?
TEMP??
RATE
TEMP
Setup (Calibration, Preconditioning) or Testing (Temperature, Rate)?
SETUP?
SETUP
TESTING

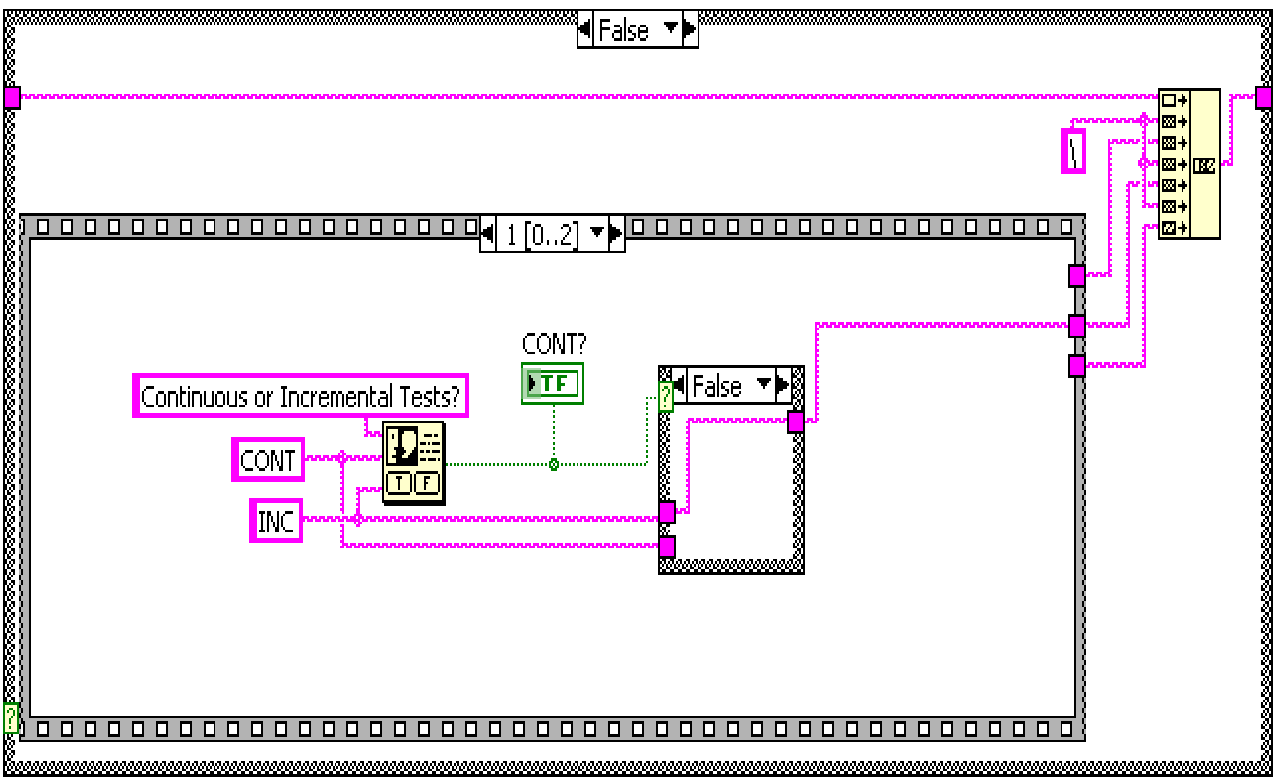

False
Temperature or Rate Tests?
TEMP
RATE
TEMP??
True
True
False

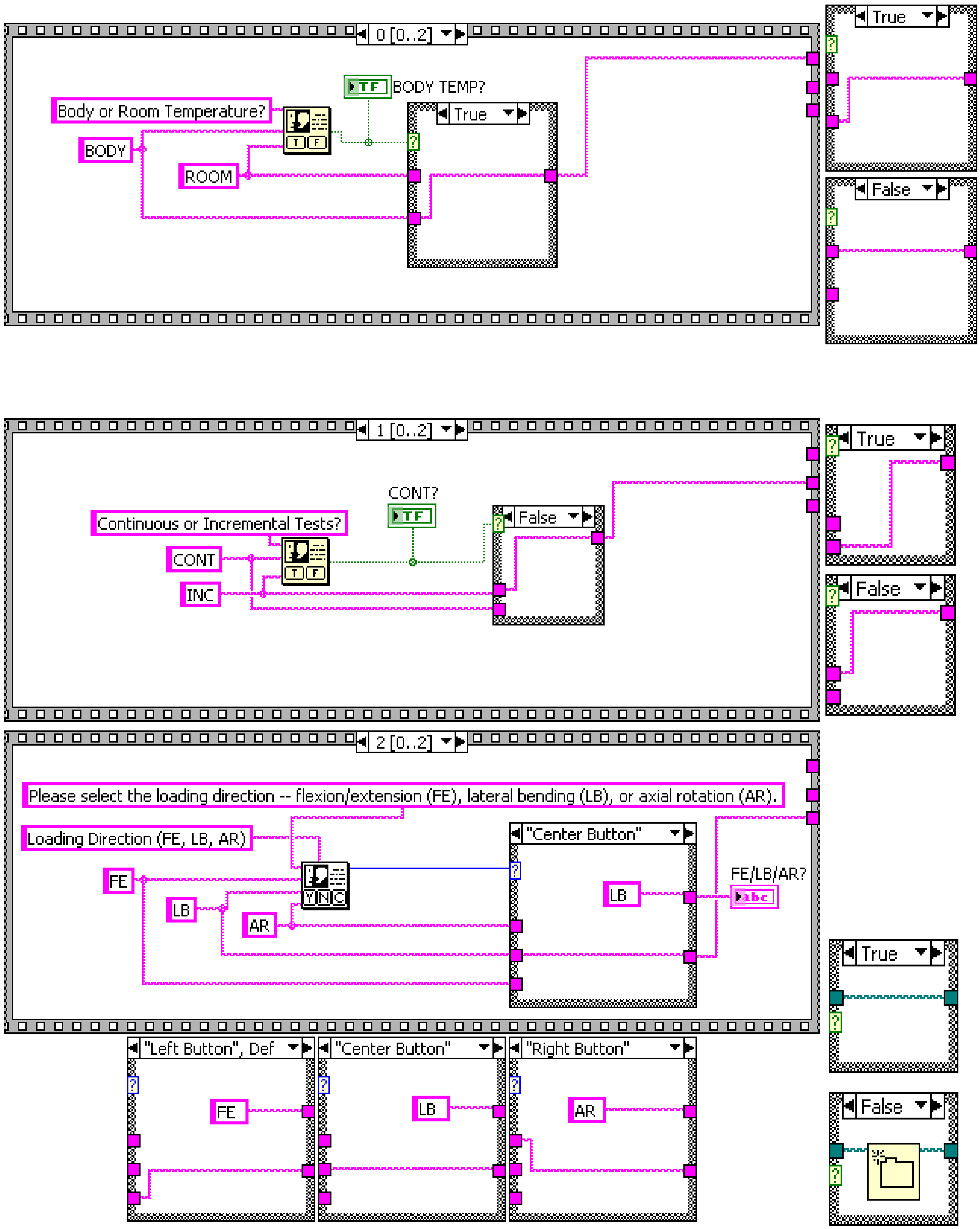

True
Calibration (CALI)
or
Preconditioning (PRE)?
CALI
PRE
False
True
False

BLOCK PANEL (Main.vi) - Dialogue 2

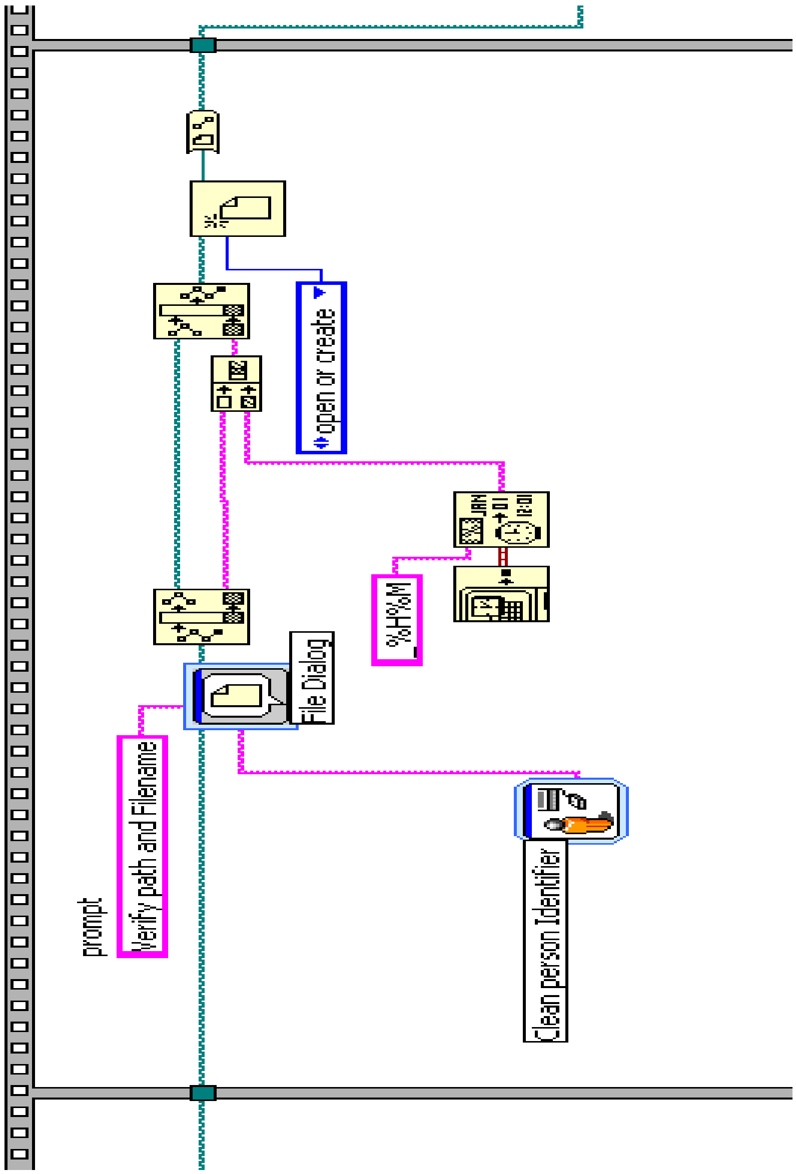



True

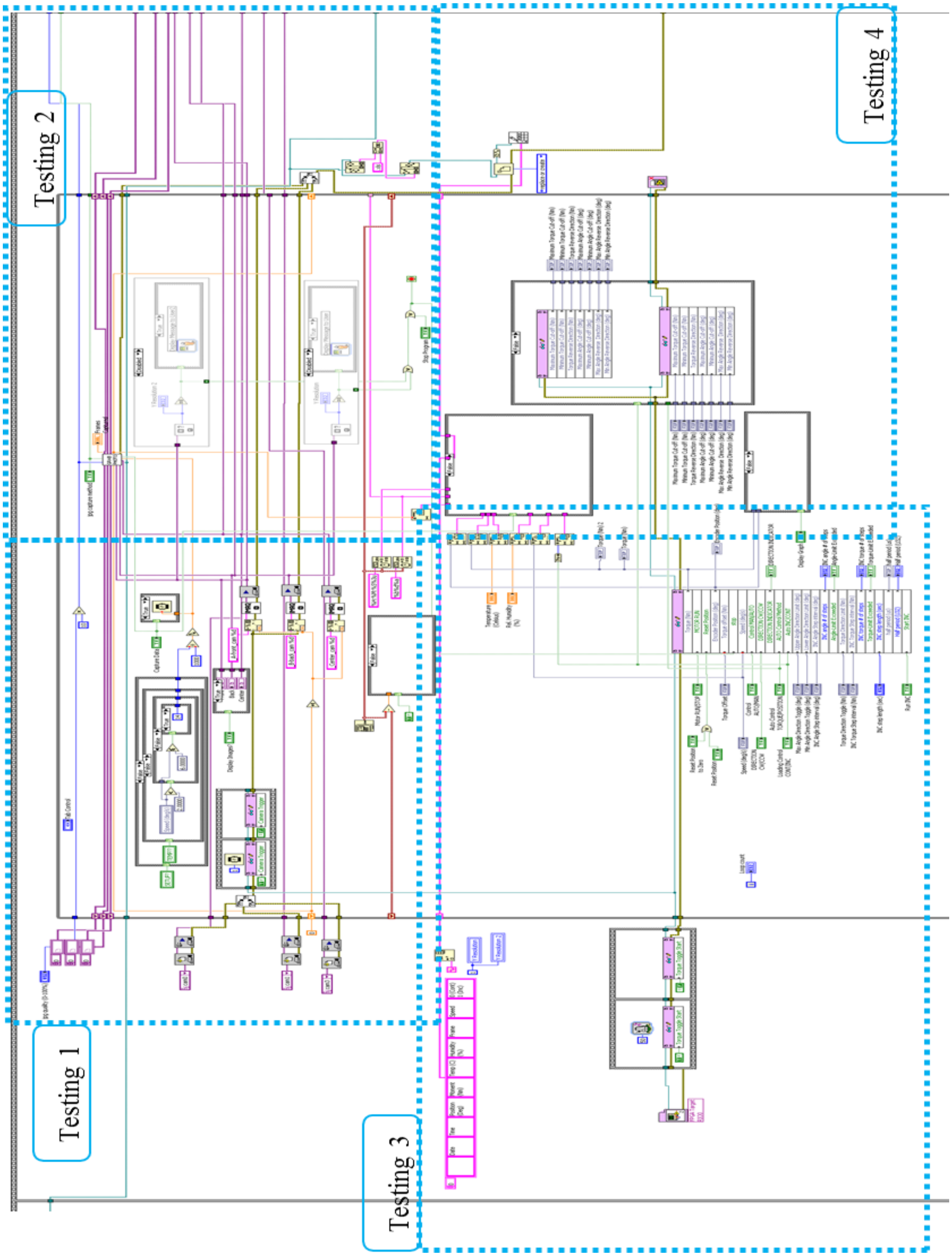

False
1 [0..2]
CONT?
Continuous or Incremental Tests?
CONT
INC
False


0 [0..2]
True
False
BODY TEMP?
Body or Room Temperature?
BODY
ROOM
1 [0..2]
CONT?
Continuous or Incremental Tests?
CONT
INC
2 [0..2]
Please select the loading direction -- flexion/extension (FE), lateral bending (LB), or axial rotation (AR).
Loading Direction (FE, LB, AR)
FE
LB
AR
"Center Button"
FE/LB/AR?
"Left Button", Def
"Right Button"

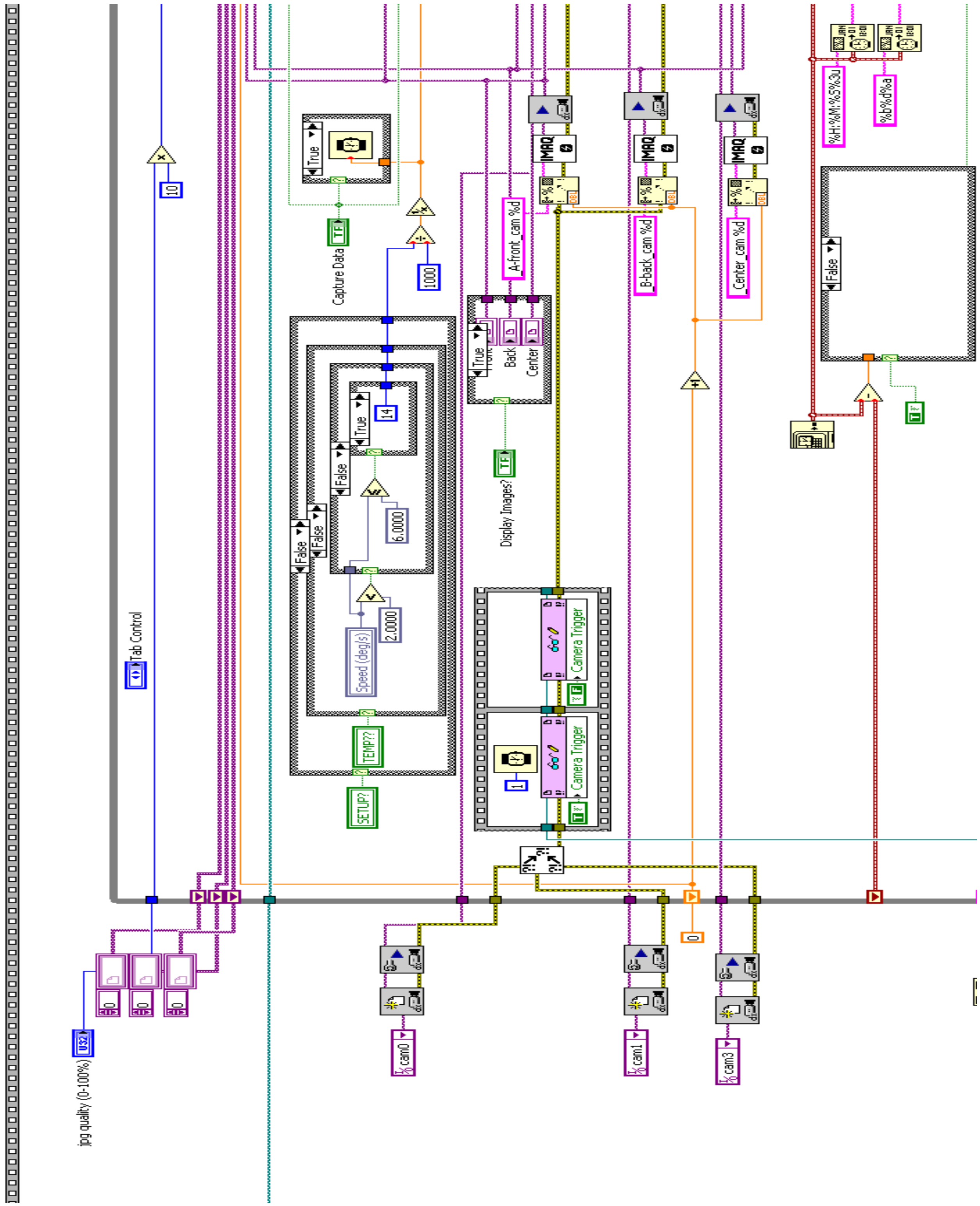
BLOCK PANEL (Main.vi) – Dialogue 3

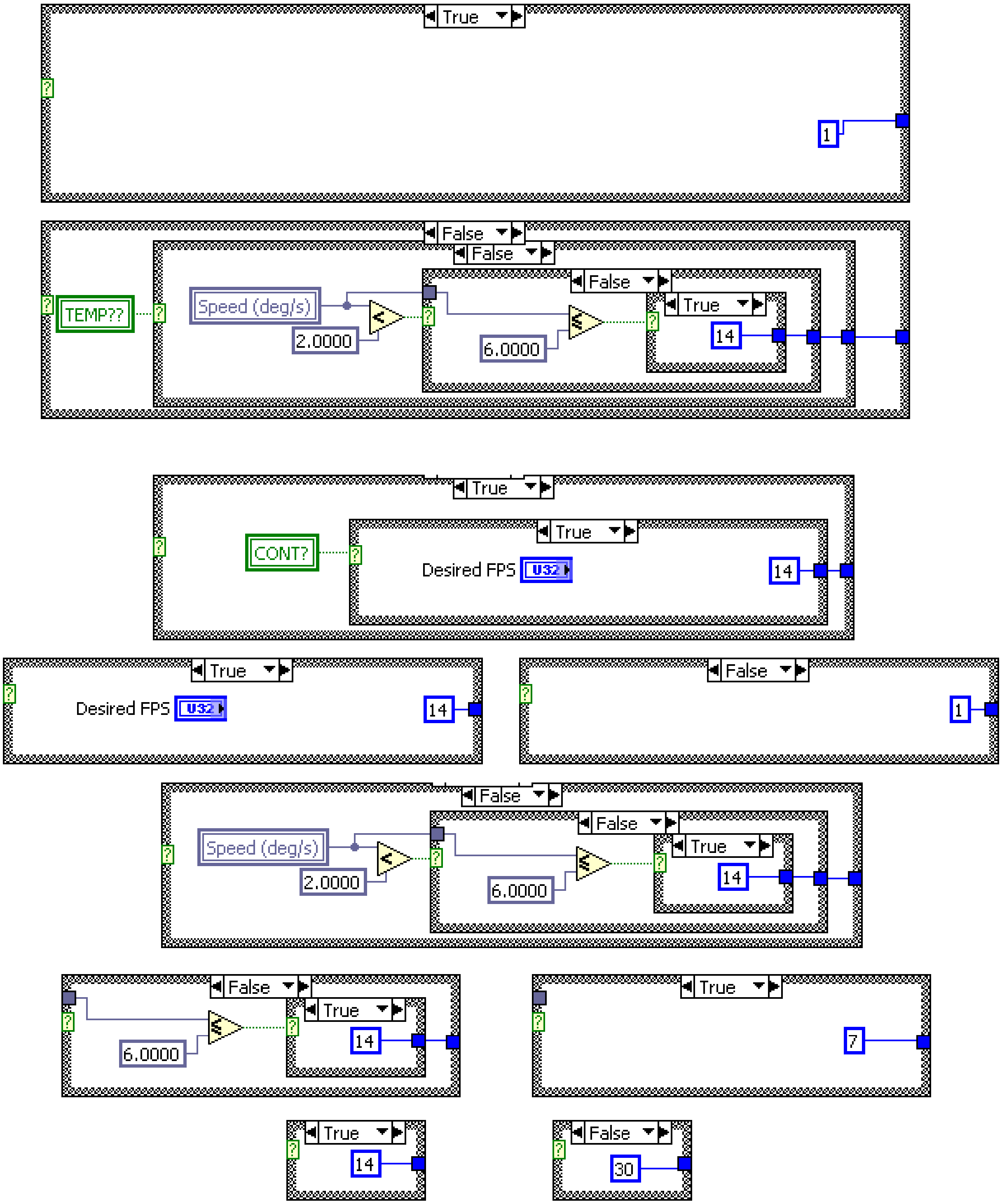


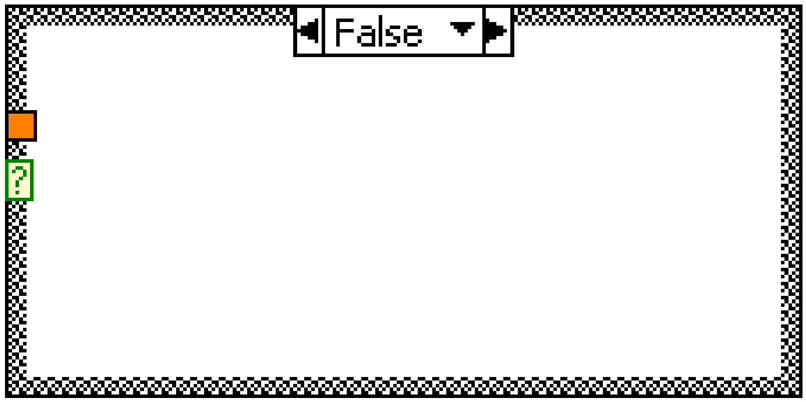
BLOCK PANEL (Main.vi) – Testing

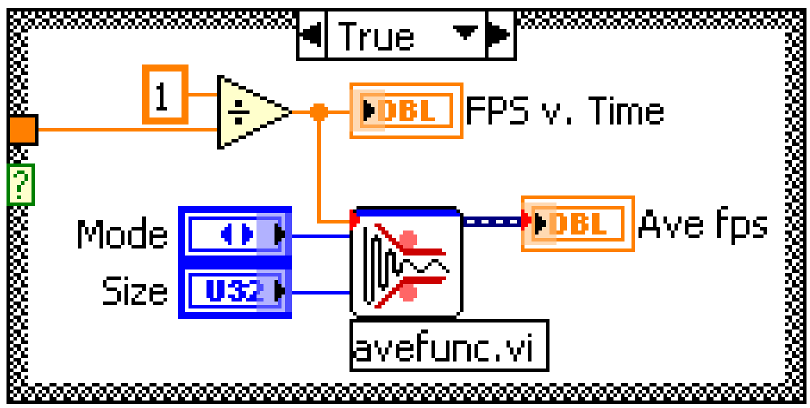


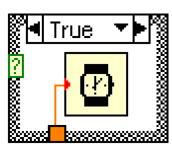
BLOCK PANEL (Main.vi) – Testing 1

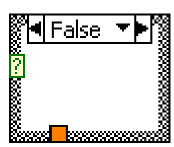


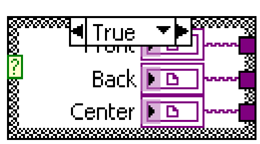

True
1
False
False
TEMP??
Speed (deg/s)
2.0000
False
6.0000
True
14
True
CONT?
True
Desired FPS
U32
14
True
Desired FPS
U32
14
False
1
False
Speed (deg/s)
2.0000
False
6.0000
True
14
False
True
6.0000
14
True
7
True
14
False
30

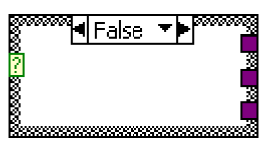

False


True
1
DBL
FPS v. Time
Mode
Size
U32
DBL
Ave fps
avefunc.vi

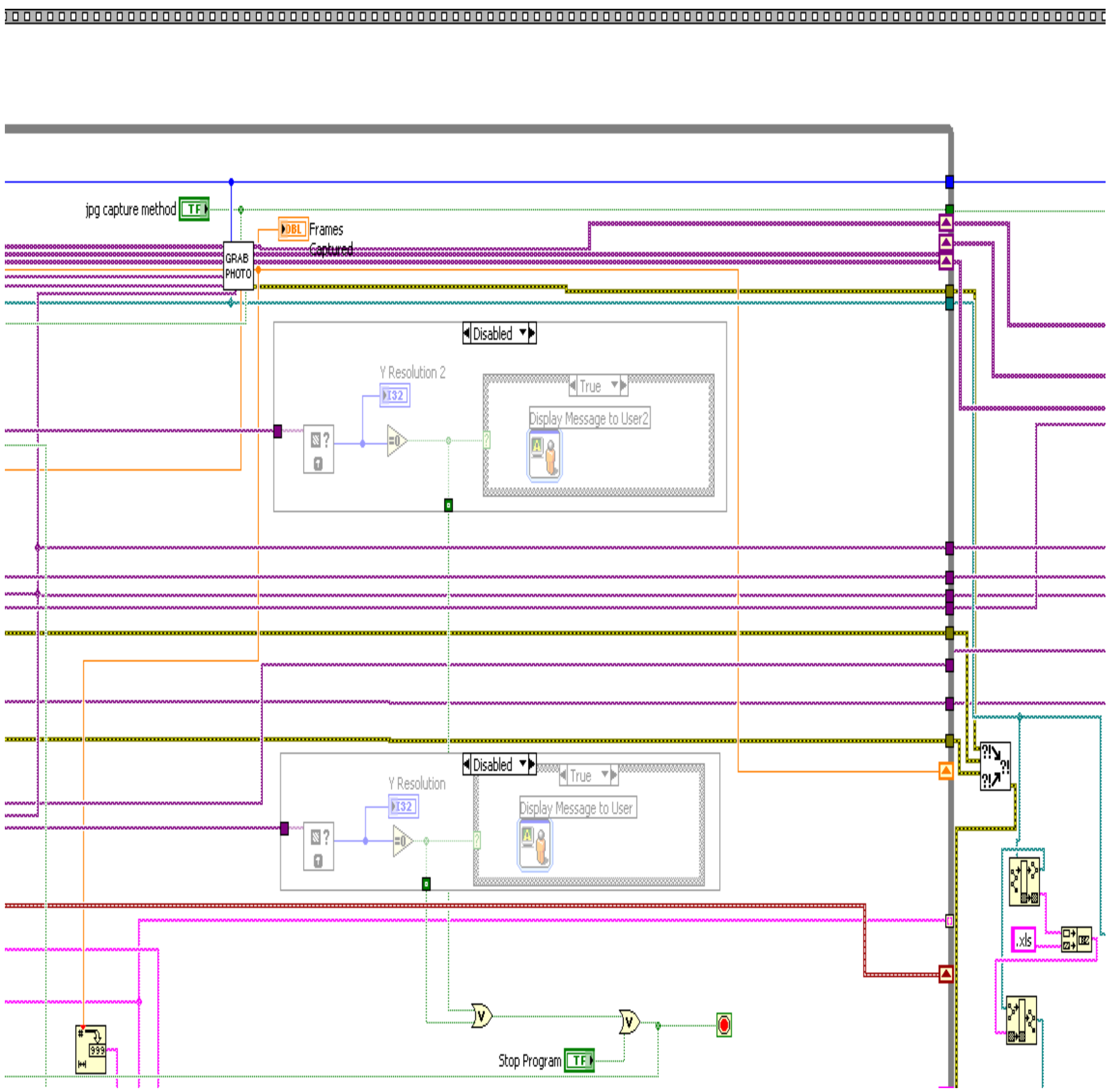

True

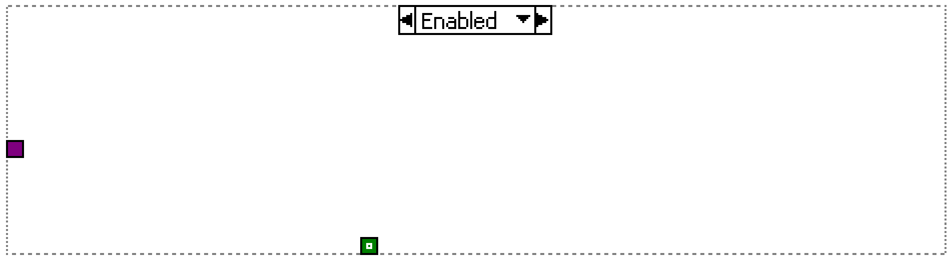

False

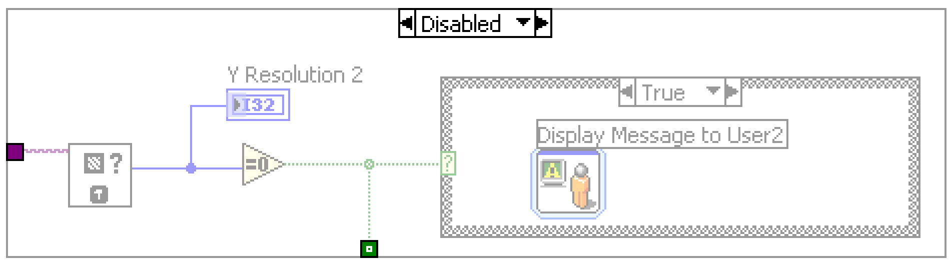

True
Back
Center

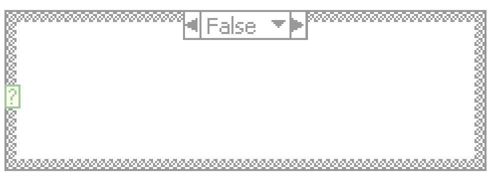

False

BLOCK PANEL (Main.vi) – Testing 2

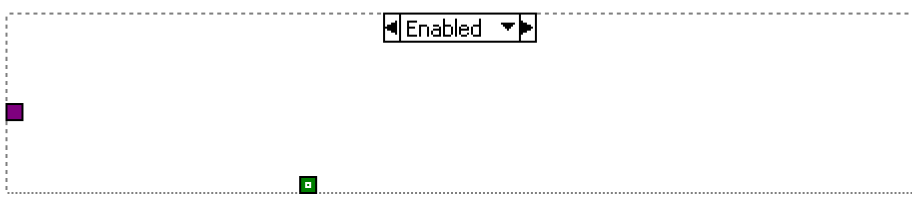


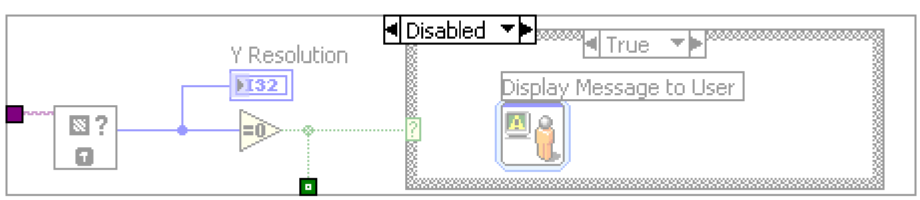

Enabled

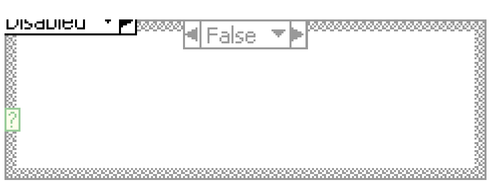

Disabled
Y Resolution 2
I32
=0
True
Display Message to User2


False


True
Display Message to User2

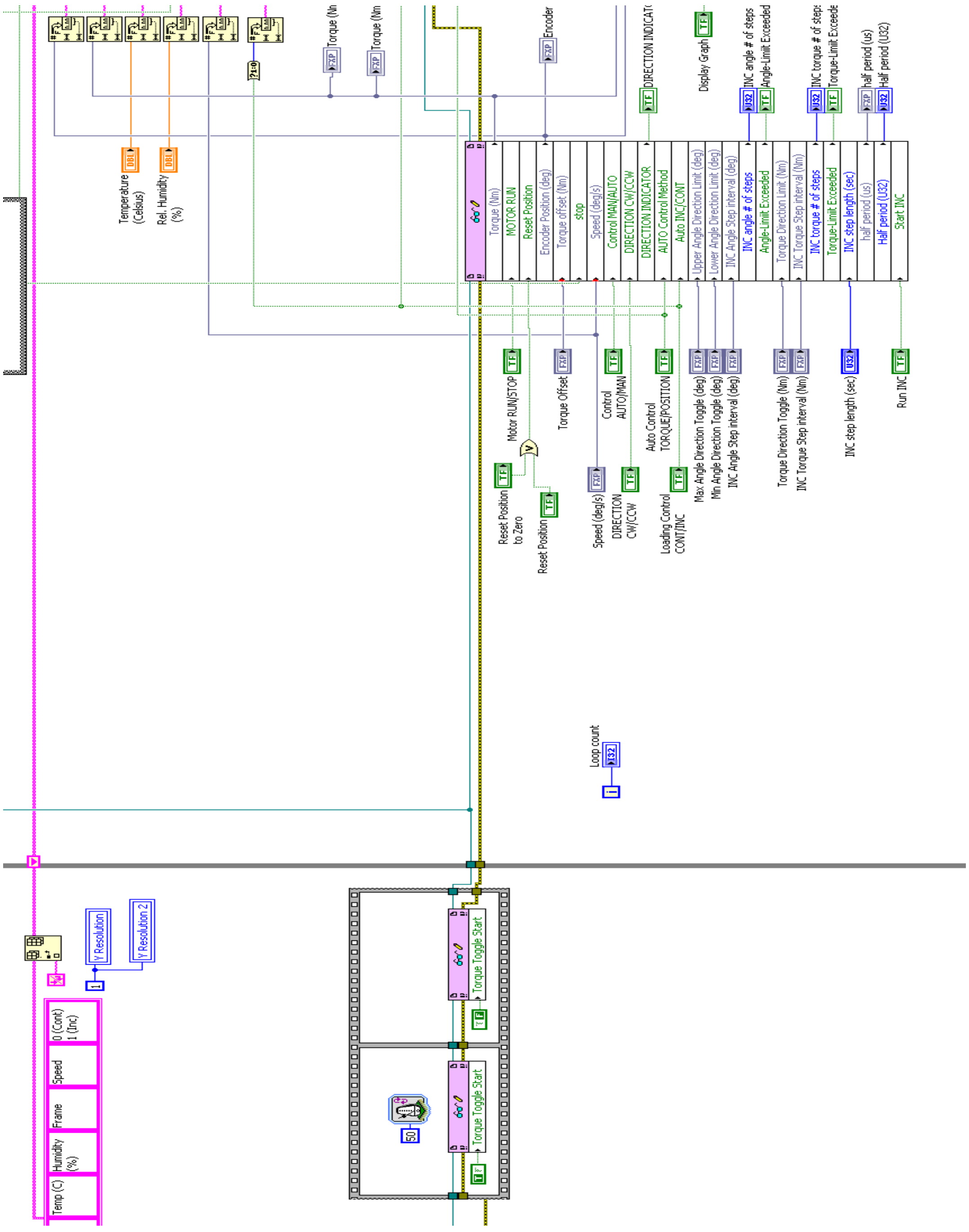

Enabled

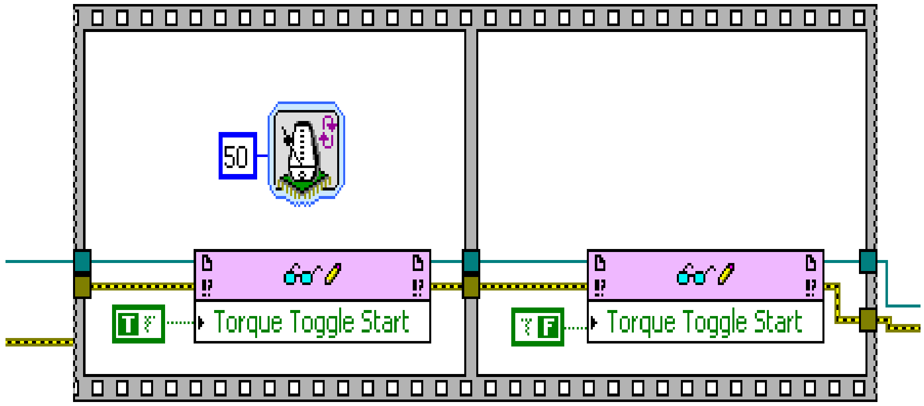

Disabled
Y Resolution
I32
=0
True
Display Message to User


False

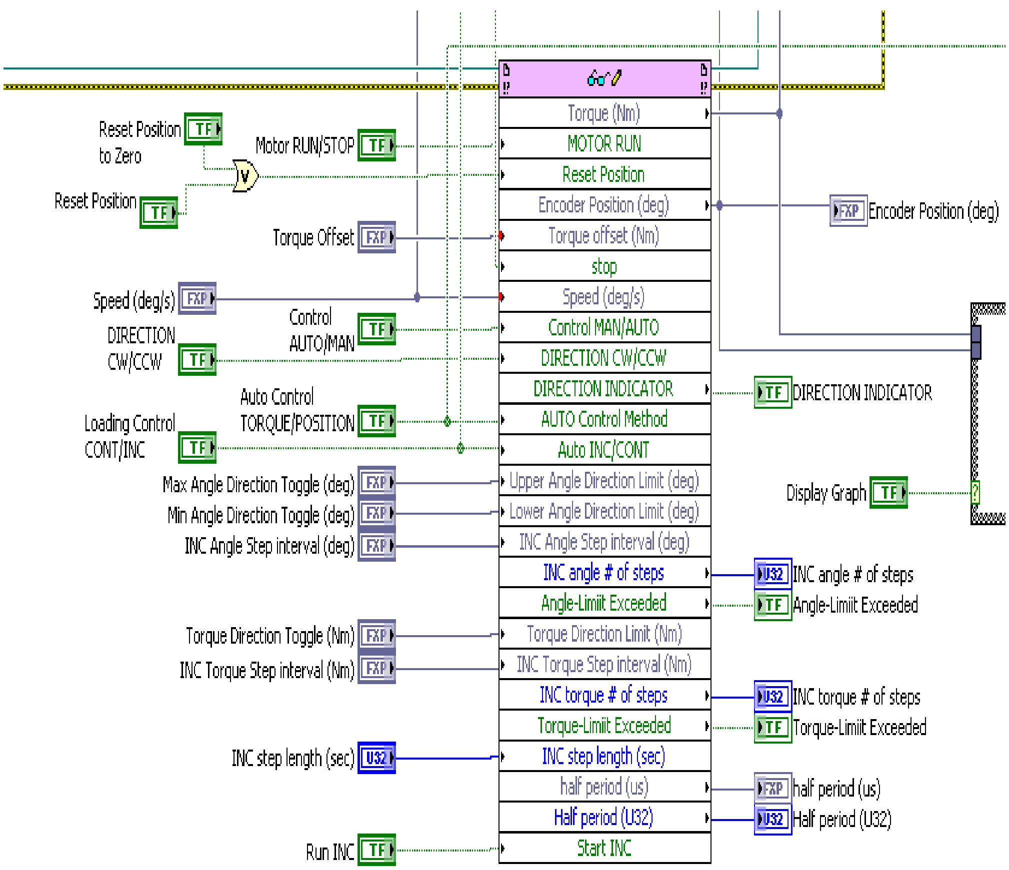

True
Display Message to User

BLOCK PANEL (Main.vi) – Testing 3



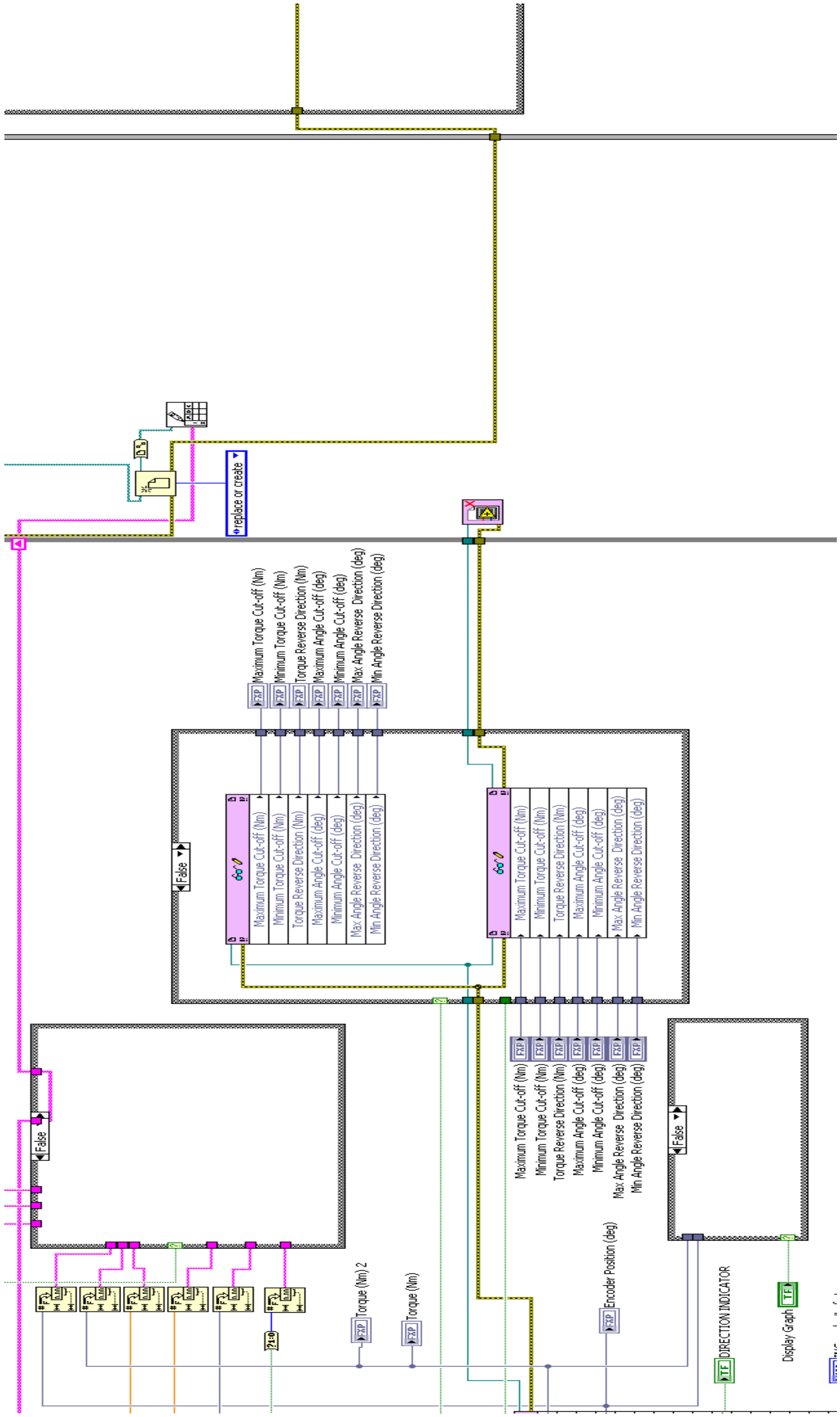


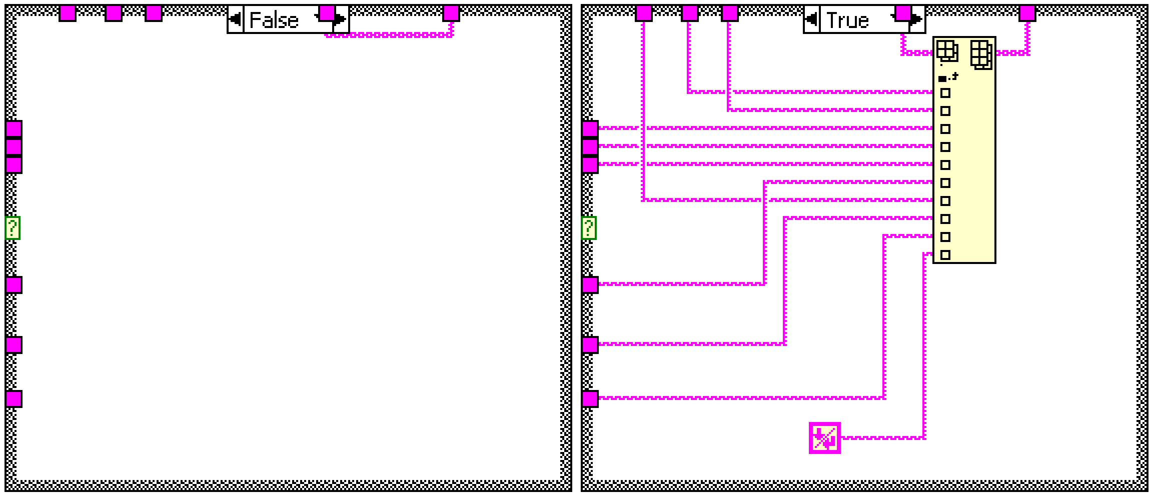
50
Torque Toggle Start
Torque Toggle Start

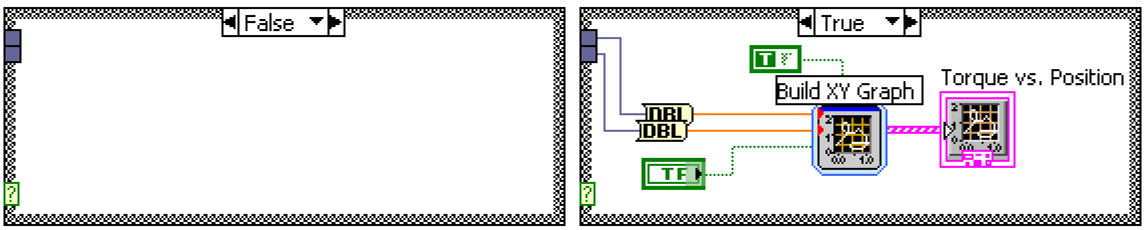


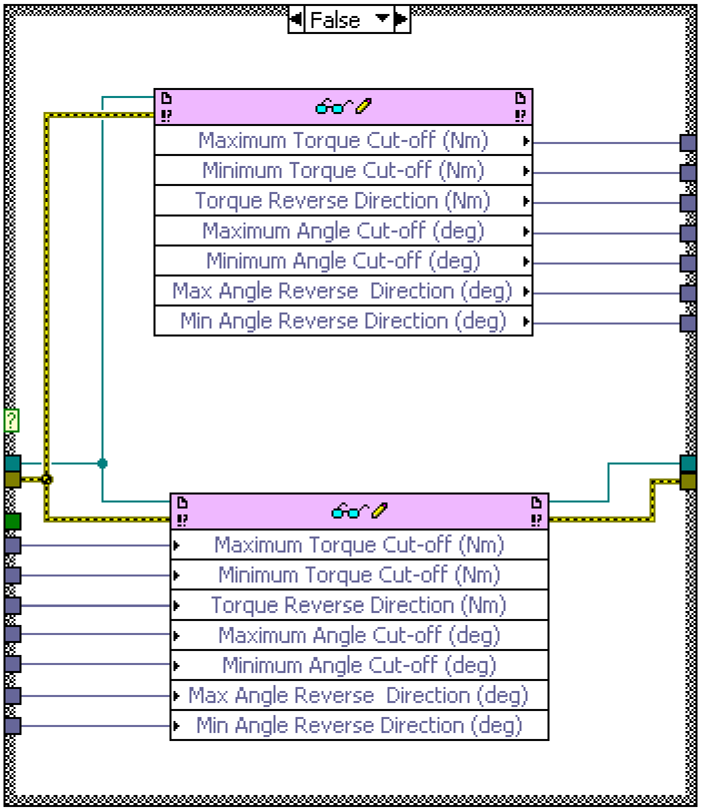
Torque (Nm)
MOTOR RUN
Reset Position
Encoder Position (deg)
Torque offset (Nm)
stop
Speed (deg/s)
Control MAN/AUTO
DIRECTION CW/CCW
DIRECTION INDICATOR
AUTO Control Method
Auto INC/CONT
Upper Angle Direction Limit (deg)
Lower Angle Direction Limit (deg)
INC Angle Step interval (deg)
INC angle # of steps
Angle-Limit Exceeded
Torque Direction Limit (Nm)
INC Torque Step interval (Nm)
INC torque # of steps
Torque-Limit Exceeded
INC step length (sec)
half period (us)
Half period (U32)
Start INC
Reset Position to Zero
Motor RUN/STOP
Reset Position
Torque Offset
Speed (deg/s)
Control AUTO/MAN
DIRECTION CW/CCW
Auto Control TORQUE/POSITION
Loading Control CONT/INC
Max Angle Direction Toggle (deg)
Min Angle Direction Toggle (deg)
INC Angle Step interval (deg)
Torque Direction Toggle (Nm)
INC Torque Step interval (Nm)
INC step length (sec)
Run INC
Encoder Position (deg)
DIRECTION INDICATOR
Display Graph
INC angle # of steps
Angle-Limit Exceeded
INC torque # of steps
Torque-Limit Exceeded
half period (us)
Half period (U32)

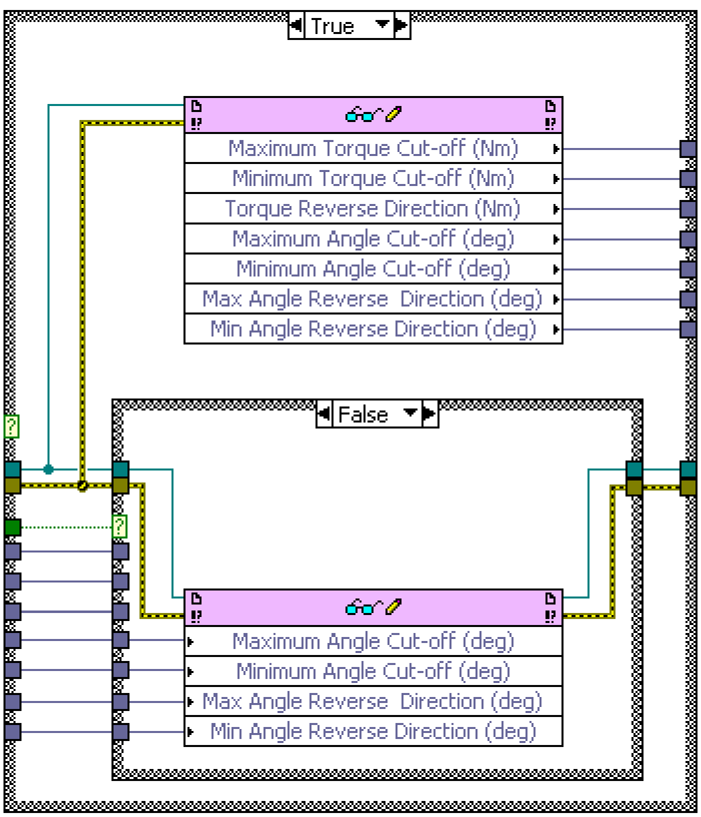
BLOCK PANEL (Main.vi) – Testing 4

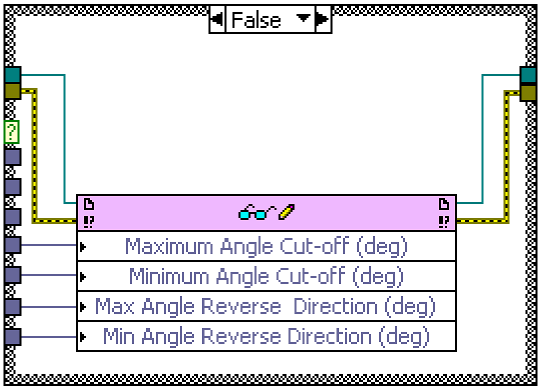


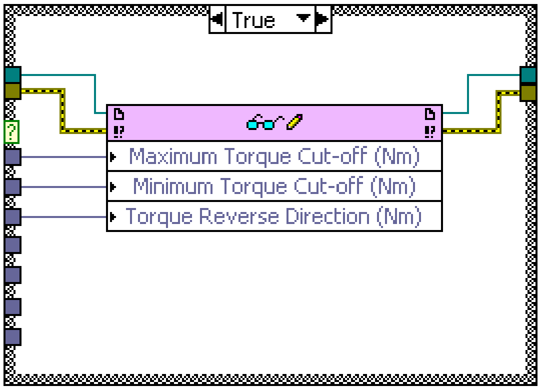

False
True


False
True
DBL
DBL
Build XY Graph
Torque vs. Position

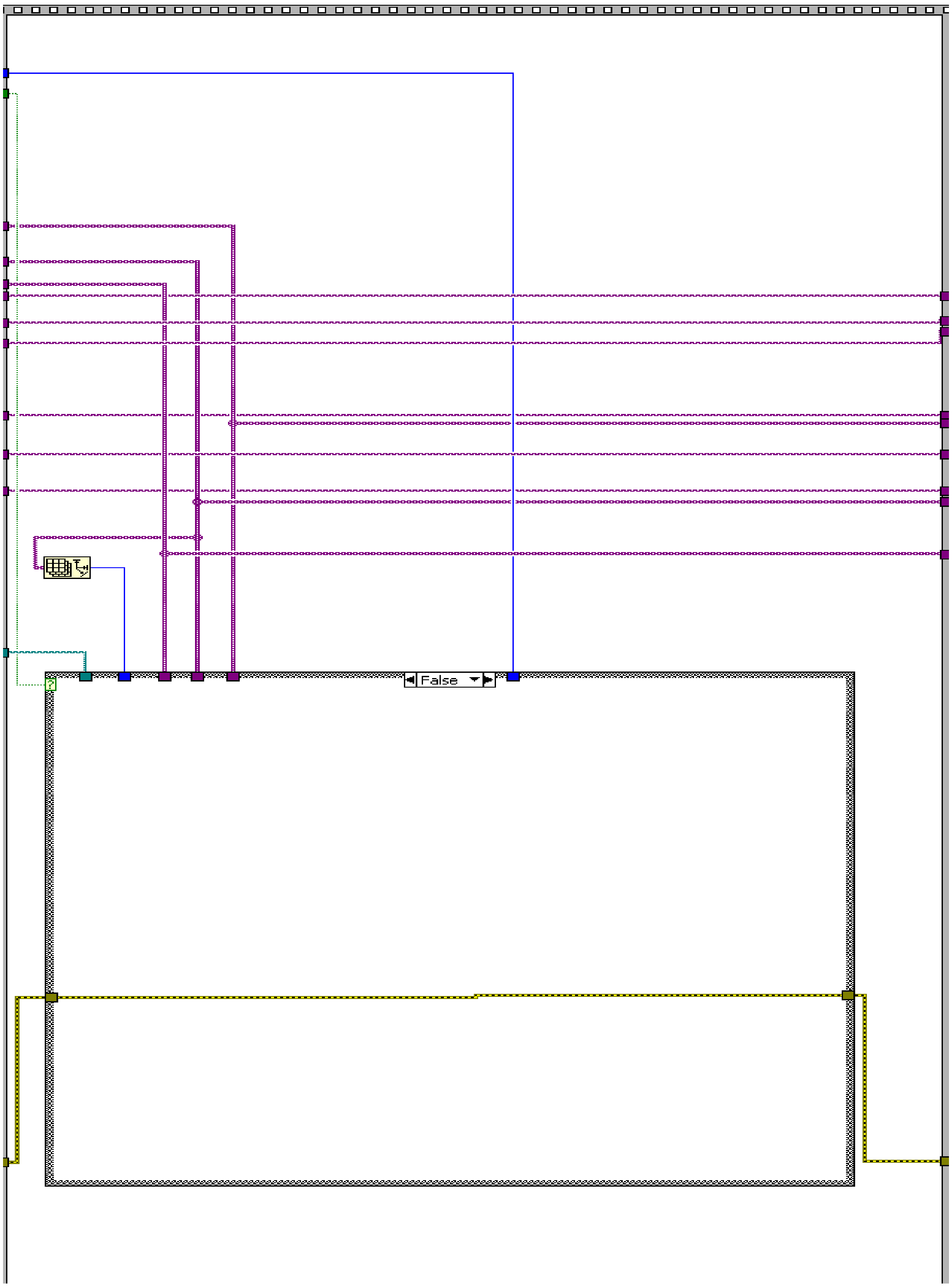

False
Maximum Torque Cut-off (Nm)
Minimum Torque Cut-off (Nm)
Torque Reverse Direction (Nm)
Maximum Angle Cut-off (deg)
Minimum Angle Cut-off (deg)
Max Angle Reverse Direction (deg)
Min Angle Reverse Direction (deg)
Maximum Torque Cut-off (Nm)
Minimum Torque Cut-off (Nm)
Torque Reverse Direction (Nm)
Maximum Angle Cut-off (deg)
Minimum Angle Cut-off (deg)
Max Angle Reverse Direction (deg)
Min Angle Reverse Direction (deg)

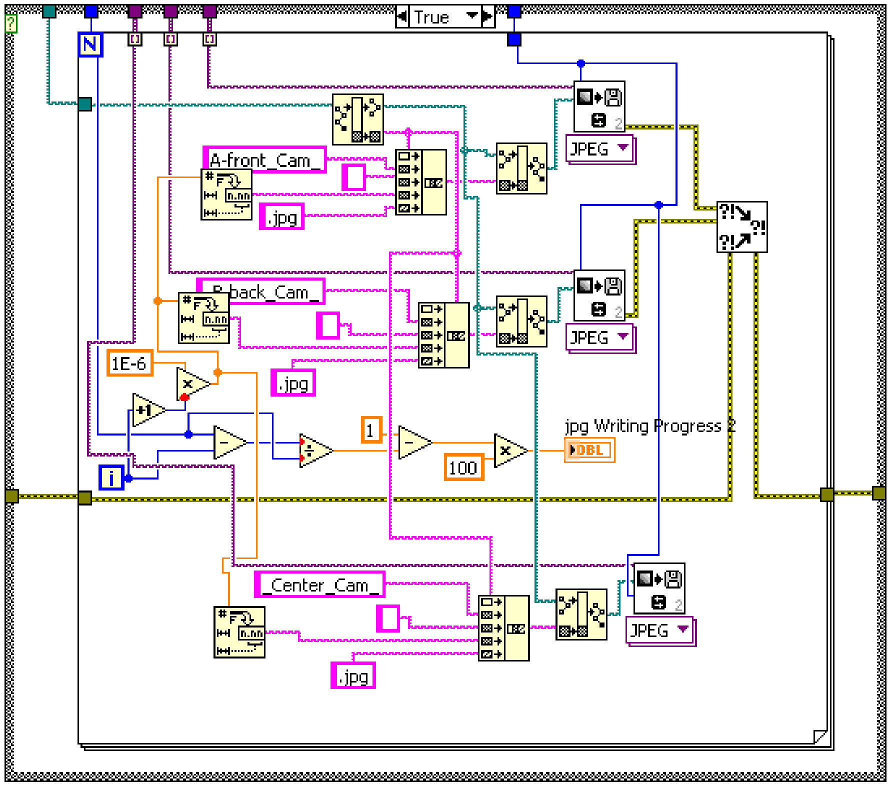

True
Maximum Torque Cut-off (Nm)
Minimum Torque Cut-off (Nm)
Torque Reverse Direction (Nm)
Maximum Angle Cut-off (deg)
Minimum Angle Cut-off (deg)
Max Angle Reverse Direction (deg)
Min Angle Reverse Direction (deg)
False
Maximum Angle Cut-off (deg)
Minimum Angle Cut-off (deg)
Max Angle Reverse Direction (deg)
Min Angle Reverse Direction (deg)

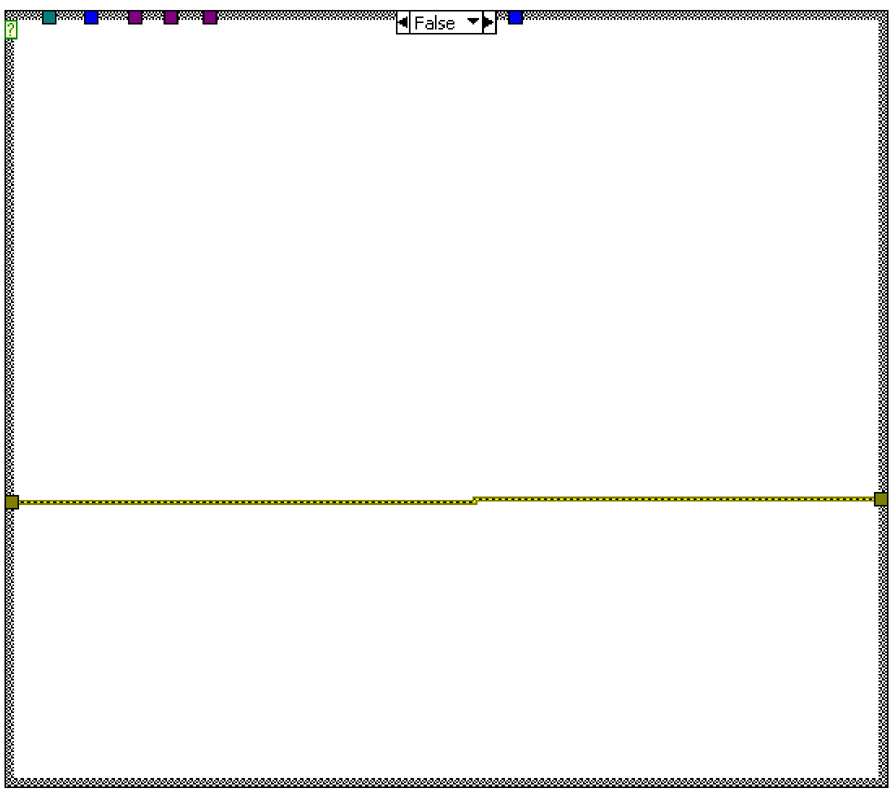

False
Maximum Angle Cut-off (deg)
Minimum Angle Cut-off (deg)
Max Angle Reverse Direction (deg)
Min Angle Reverse Direction (deg)


True
Maximum Torque Cut-off (Nm)
Minimum Torque Cut-off (Nm)
Torque Reverse Direction (Nm)

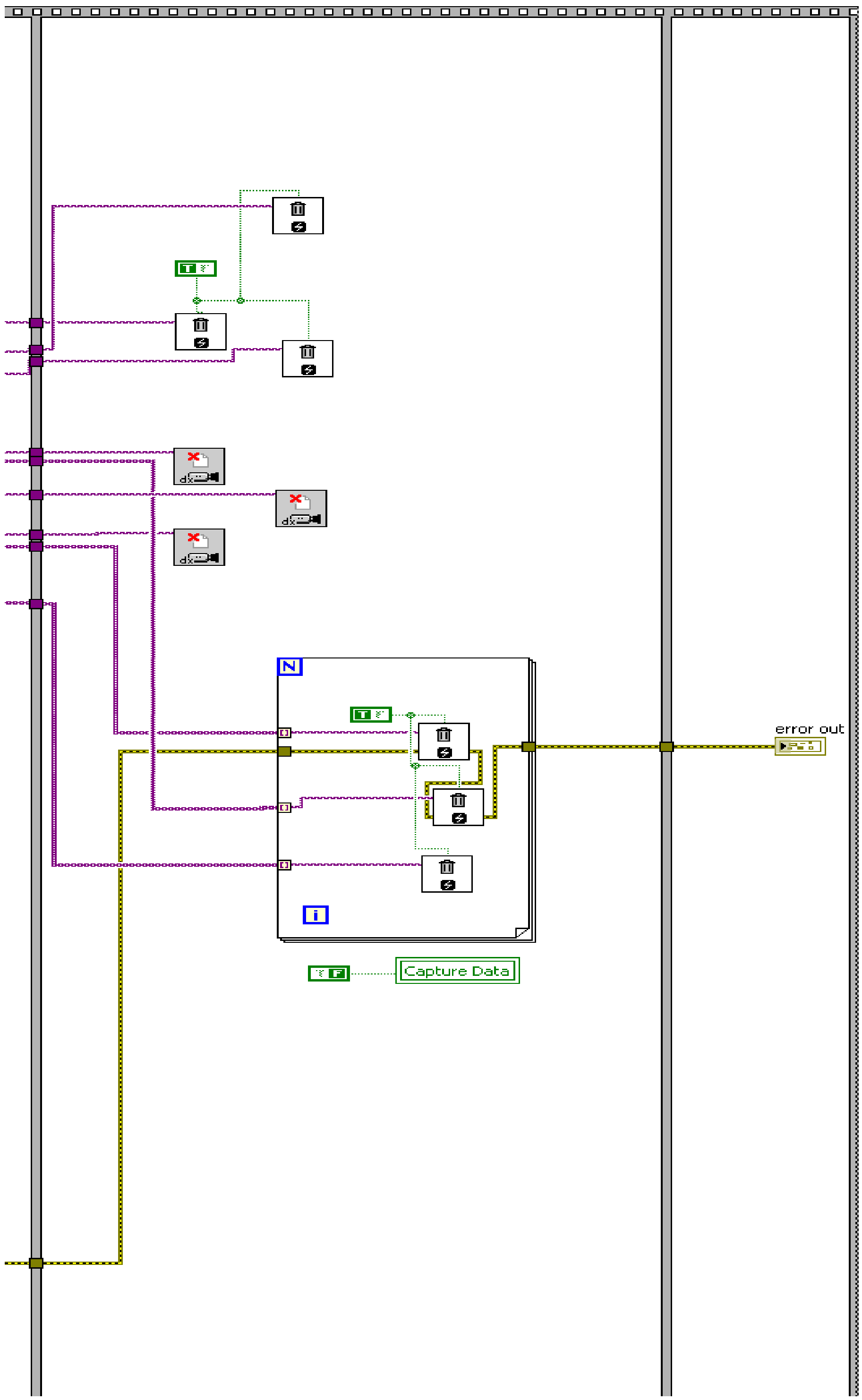
BLOCK PANEL (Main.vi) - Saving




True
A-front_Cam_
.jpg
JPEG
B-back_Cam_
1E-6
1
100
jpg Writing Progress 2
DBL
_Center_Cam_


False

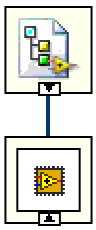
BLOCK PANEL (Main.vi) – Delete



"Main VI.vi History"

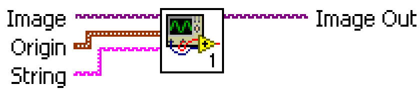
Current Revision: 304

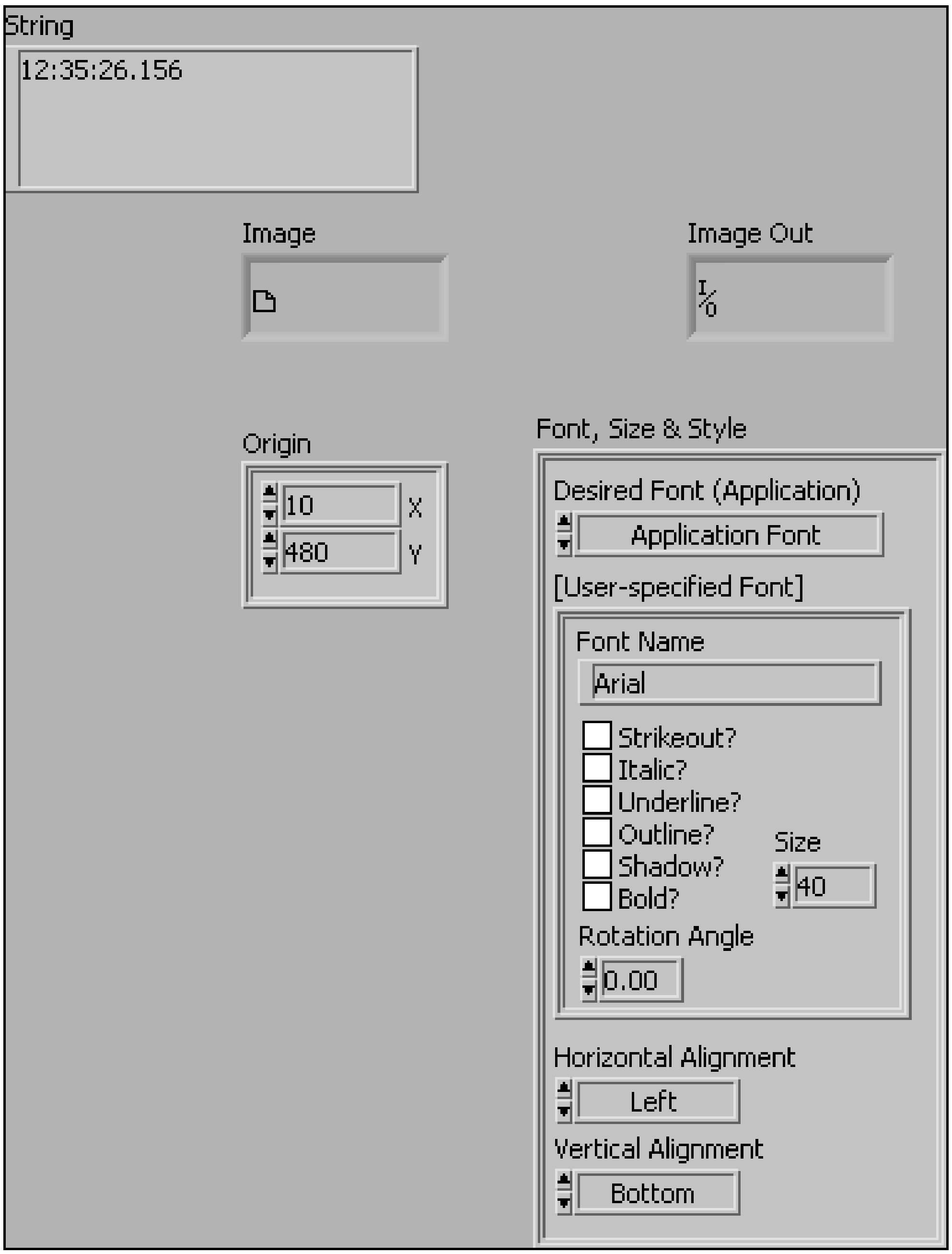
Position in Hierarchy

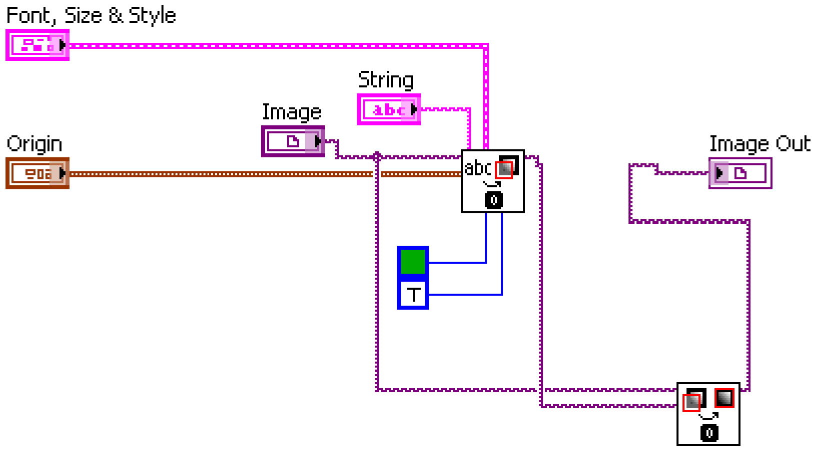


A.2.3. apply_string.vi

apply_string.vi



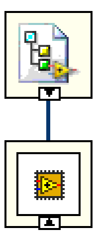




"apply_string.vi History"

Current Revision: 10

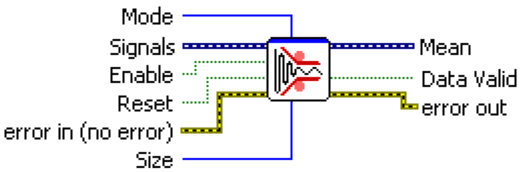
Position in Hierarchy

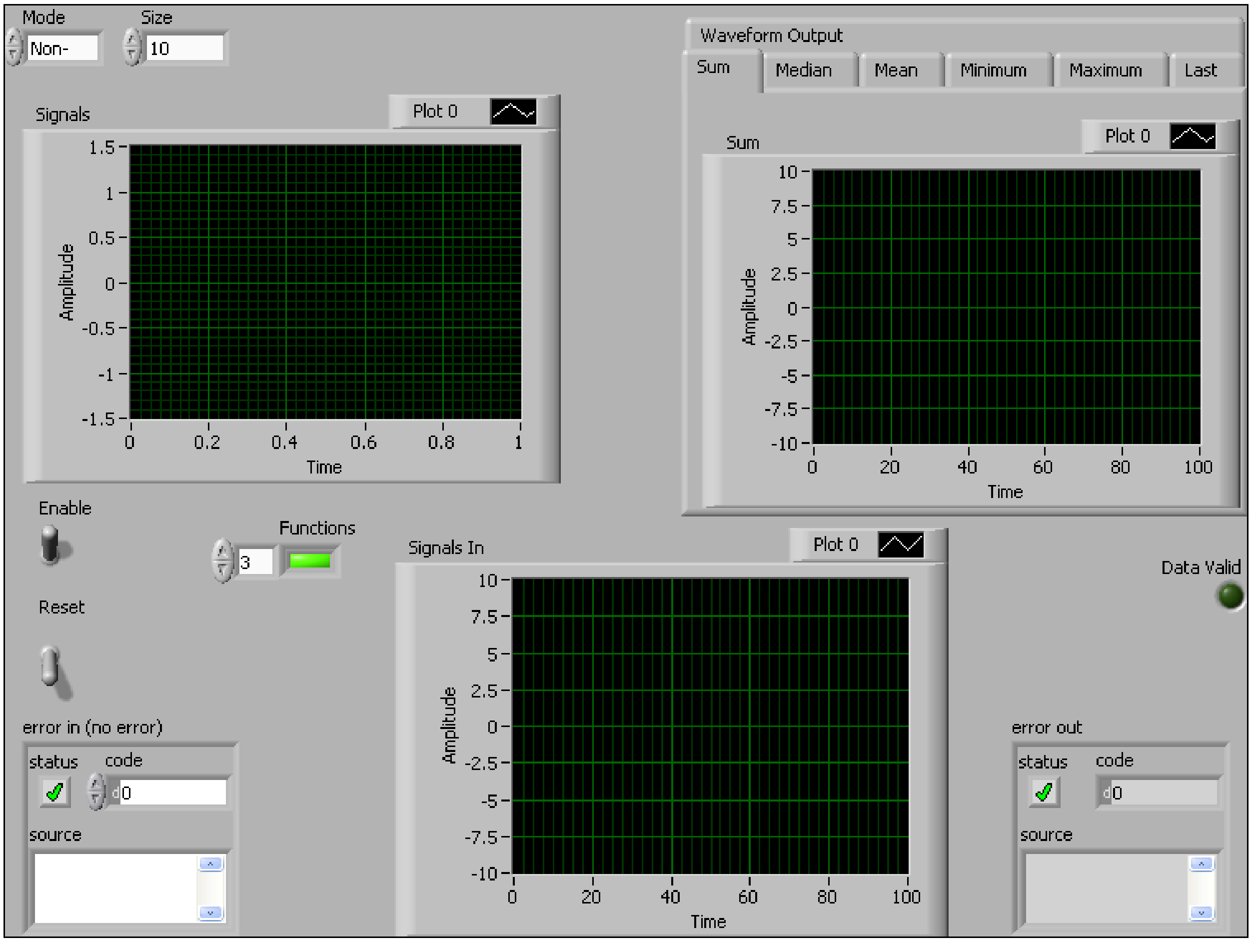


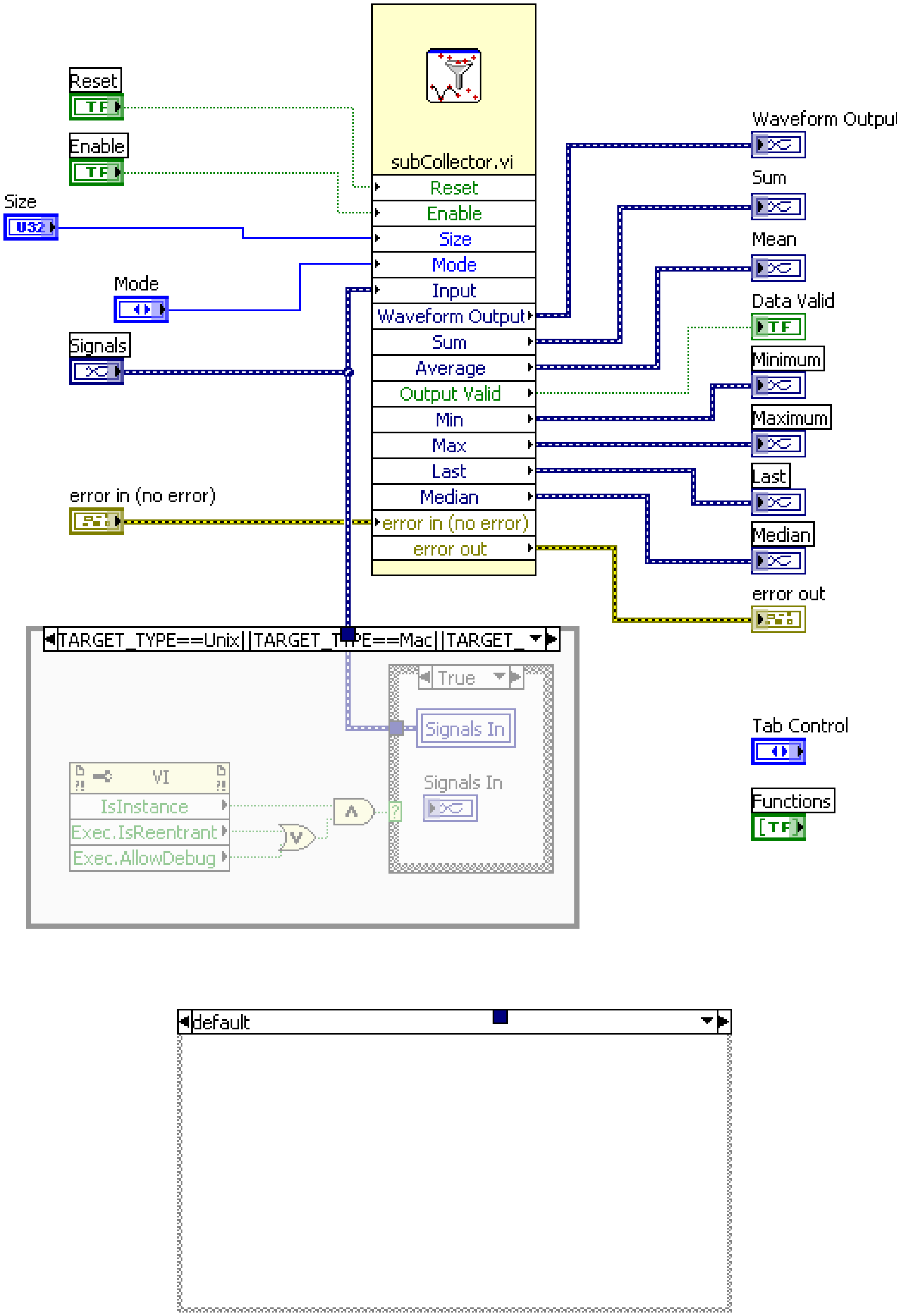
A.2.4. avefunc.vi

avefunc.vi

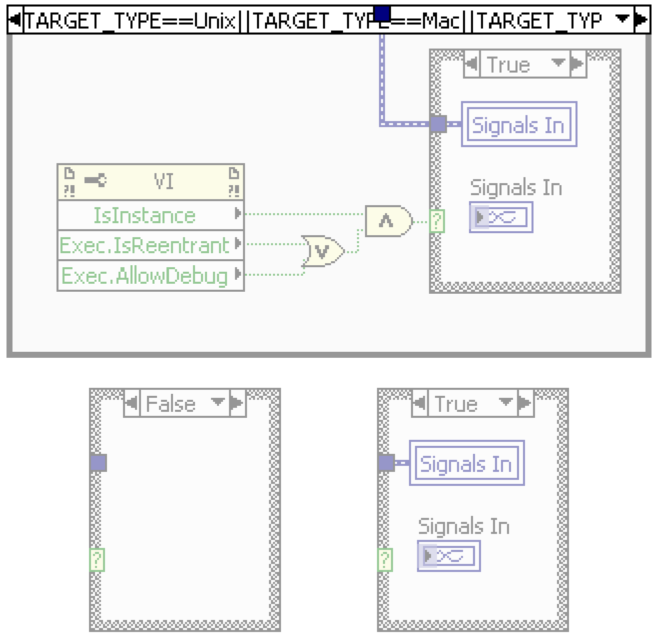
Acquires a large number of data points and compresses the data points into a smaller number of points.







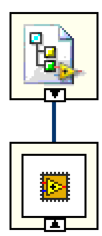
Reset
Enable
Size
Mode
Signals
error in (no error)
subCollector.vi
Reset
Enable
Size
Mode
Input
Waveform Output
Sum
Average
Output Valid
Min
Max
Last
Median
error in (no error)
error out
Waveform Output
Sum
Mean
Data Valid
Minimum
Maximum
Last
Median
error out
TARGET_TYPE==Unix||TARGET_TYPE==Mac||TARGET_
True
Signals In
Signals In
VI
IsInstance
Exec.IsReentrant
Exec.AllowDebug
Tab Control
Functions
default



"avefunc.vi History"

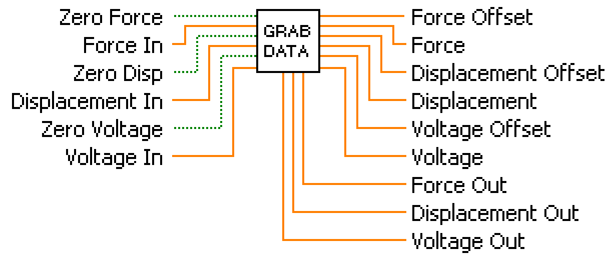
Current Revision: 24

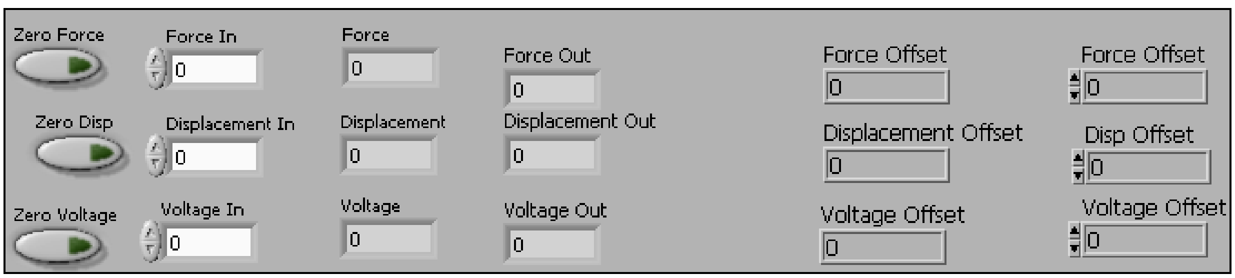
Position in Hierarchy

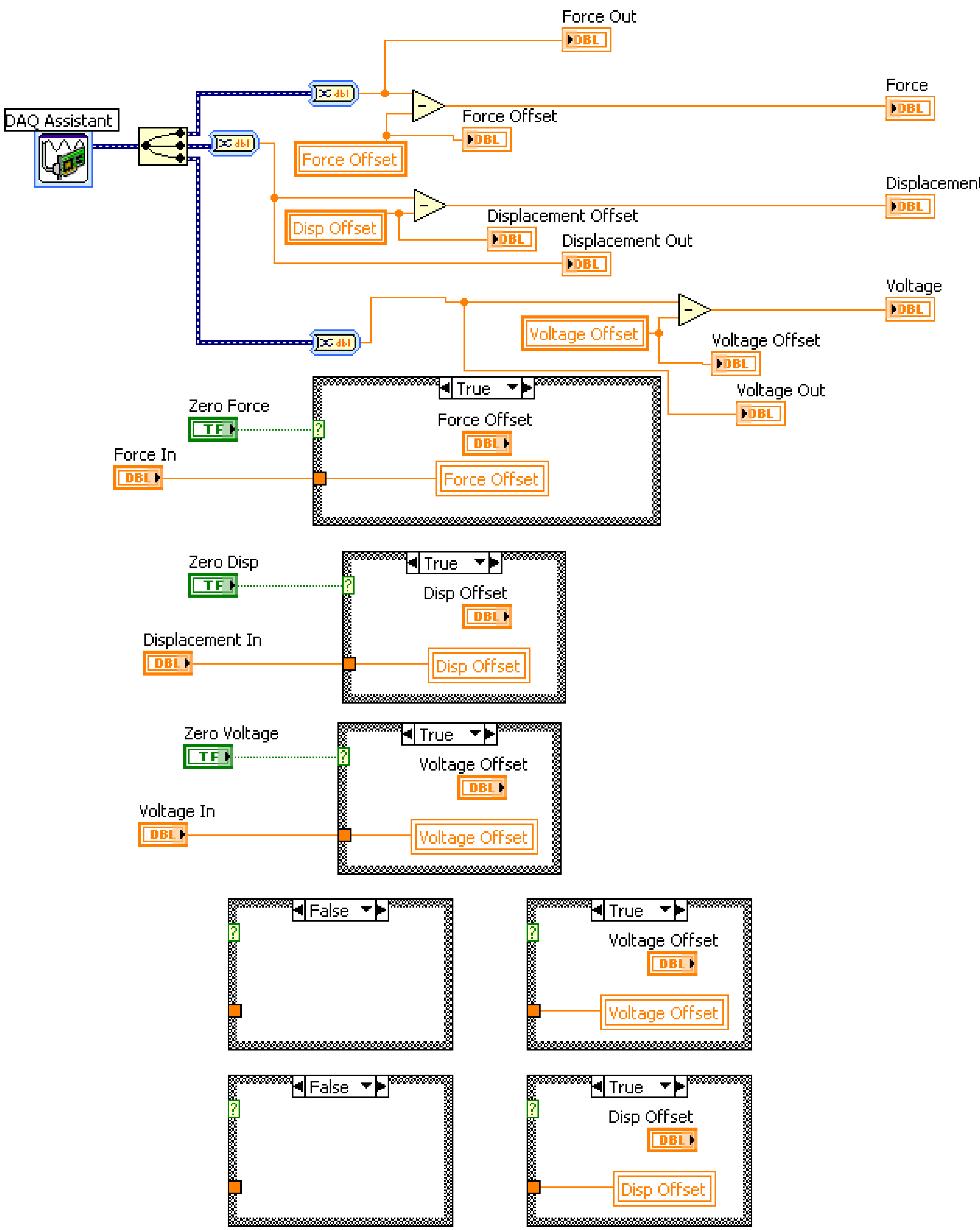


A.2.5. Grab Data.vi

Grab Data.vi






Force Out
DBL
Force
DBL
DAQ Assistant
Force Offset
DBL
Force Offset
Displacement
DBL
Disp Offset
Displacement Offset
DBL
Displacement Out
DBL
Voltage
DBL
Voltage Offset
Voltage Offset
DBL
Voltage Out
DBL
Zero Force
TF
Force In
DBL
True
Force Offset
DBL
Force Offset
Zero Disp
TF
True
Disp Offset
DBL
Displacement In
DBL
Disp Offset
Zero Voltage
TF
True
Voltage Offset
DBL
Voltage In
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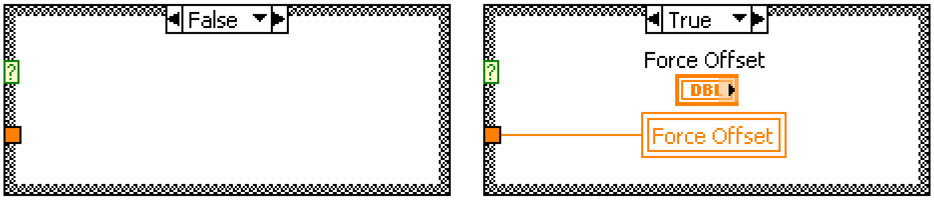
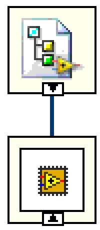
True
Disp Offset
DBL
Disp Offset



"Grab Data.vi History"

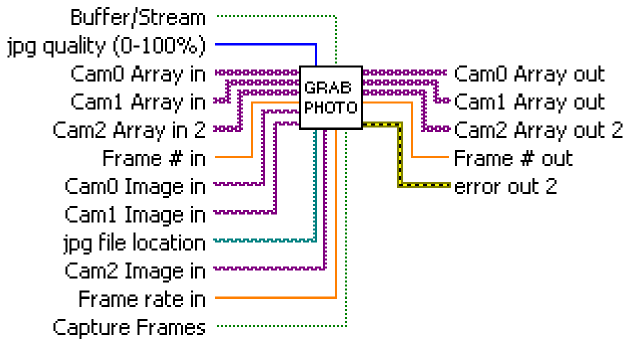
Current Revision: 13

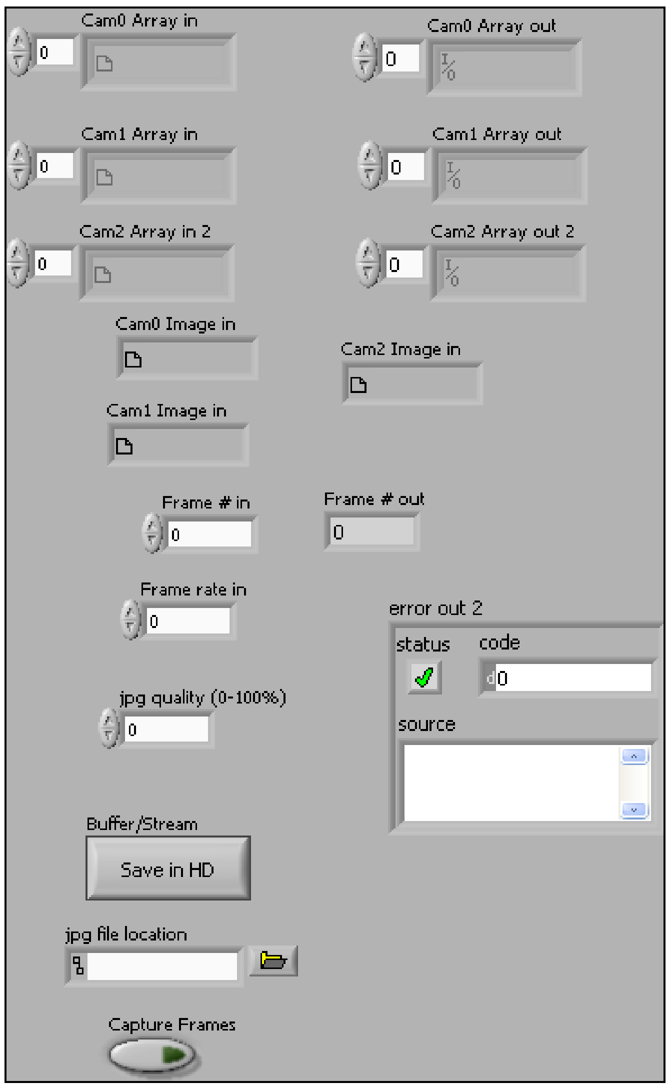
Position in Hierarchy

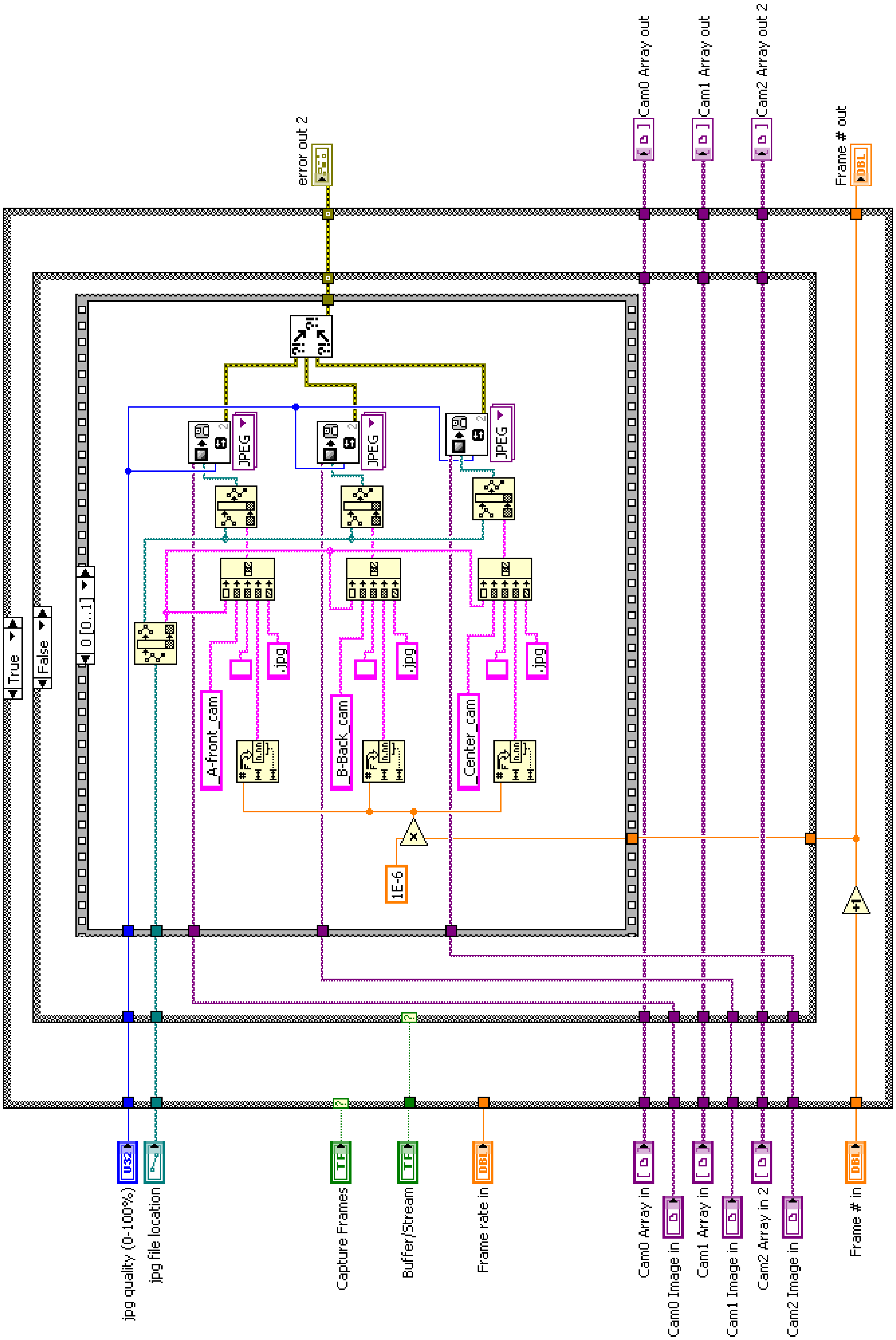


A.2.6. Grab Photo.vi

Grab Photo.vi



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Cam0 Array out
Cam1 Array out
Cam2 Array out 2
Frame # out
True
False
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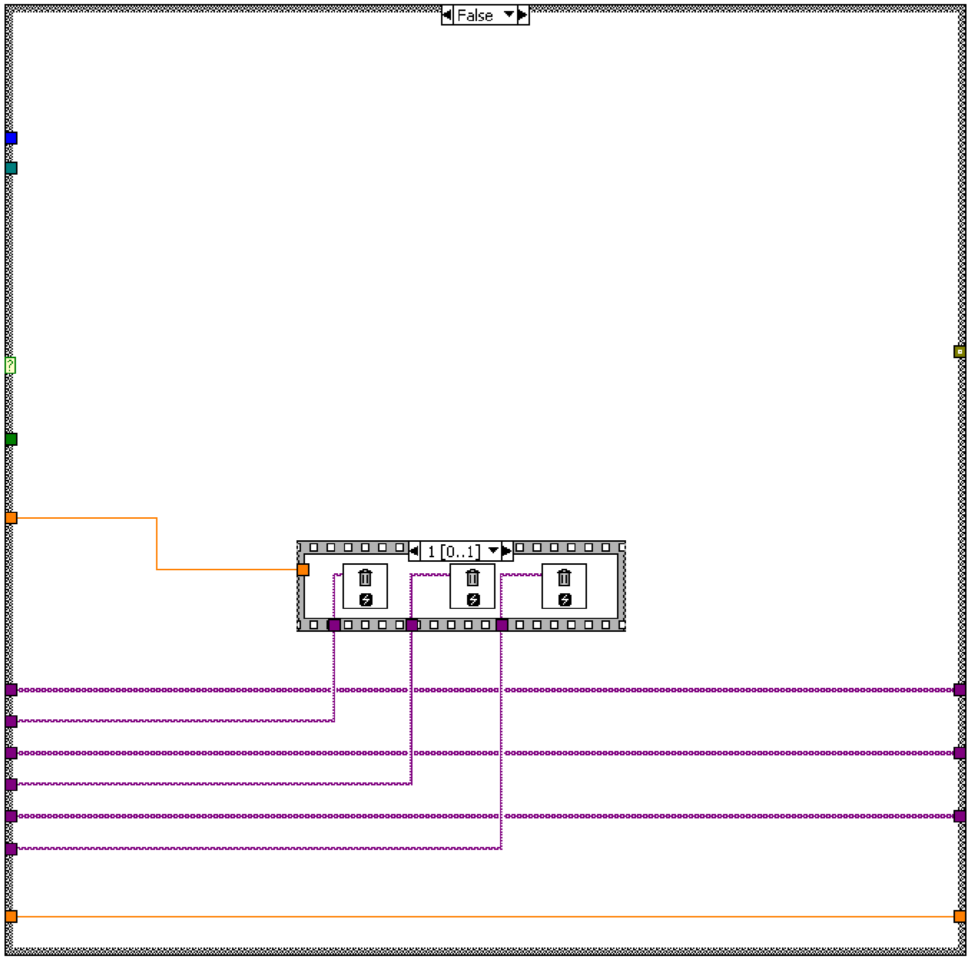
JPEG
JPEG
.jpg
.jpg
.jpg
A-front_cam
B-Back_cam
_Center_cam
1E-6
jpg quality (0-100%)
jpg file location
Capture Frames
Buffer/Stream
Frame rate in
Cam0 Array in
Cam0 Image in
Cam1 Array in
Cam1 Image in
Cam2 Array in 2
Cam2 Image in
Frame # in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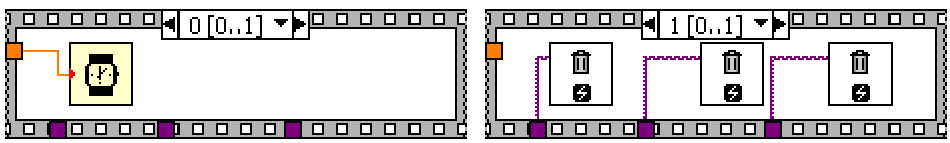
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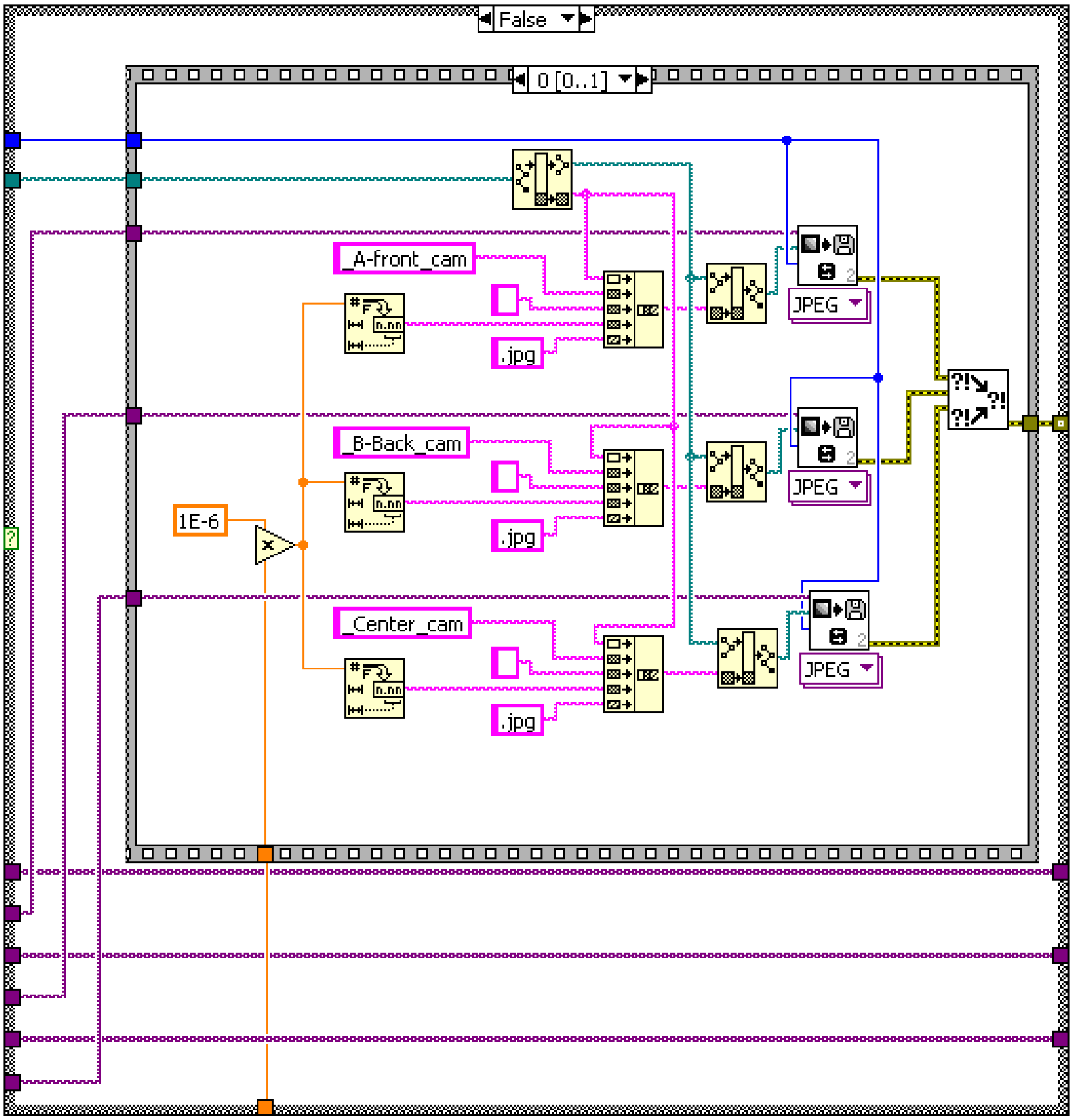

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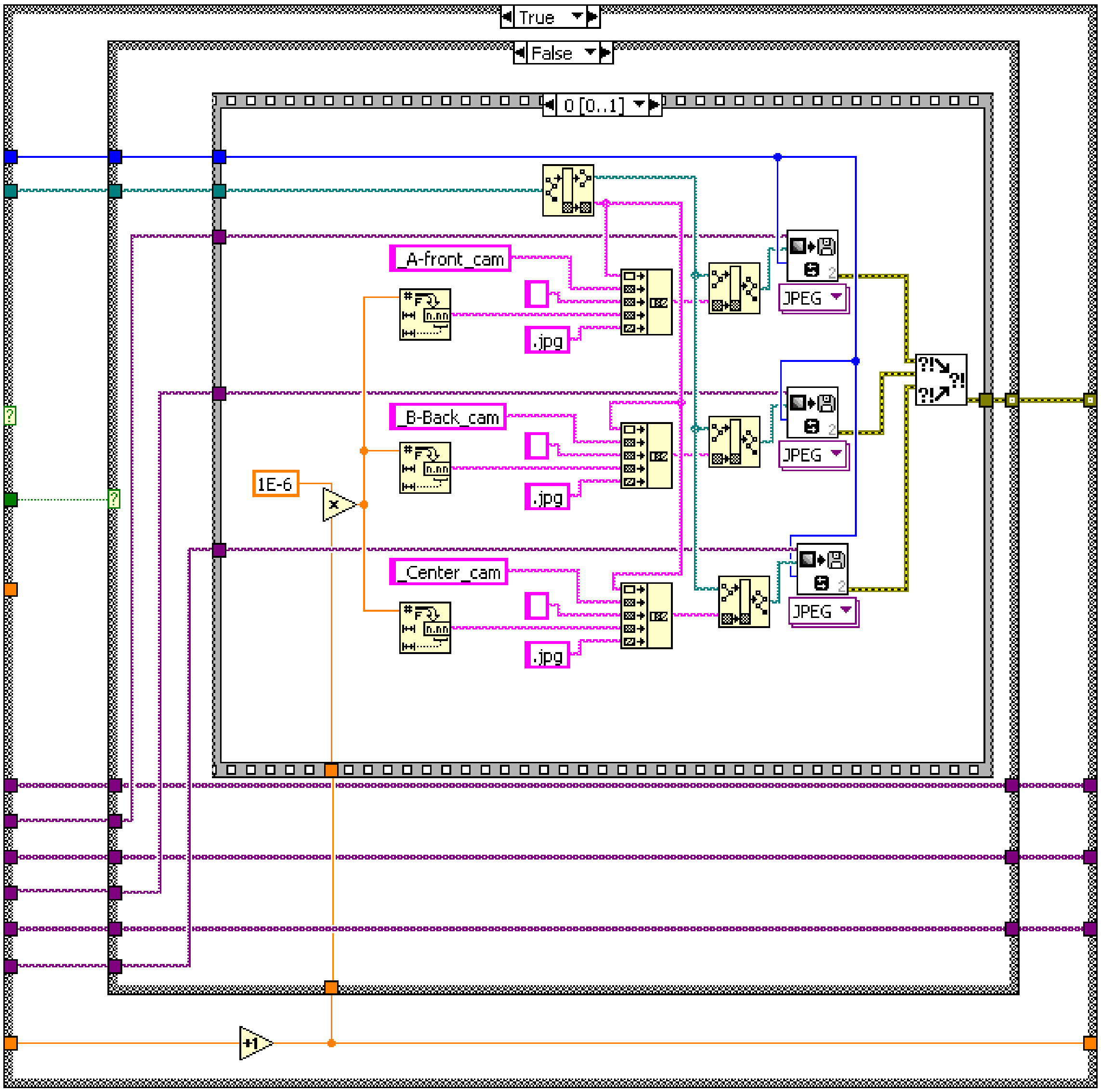
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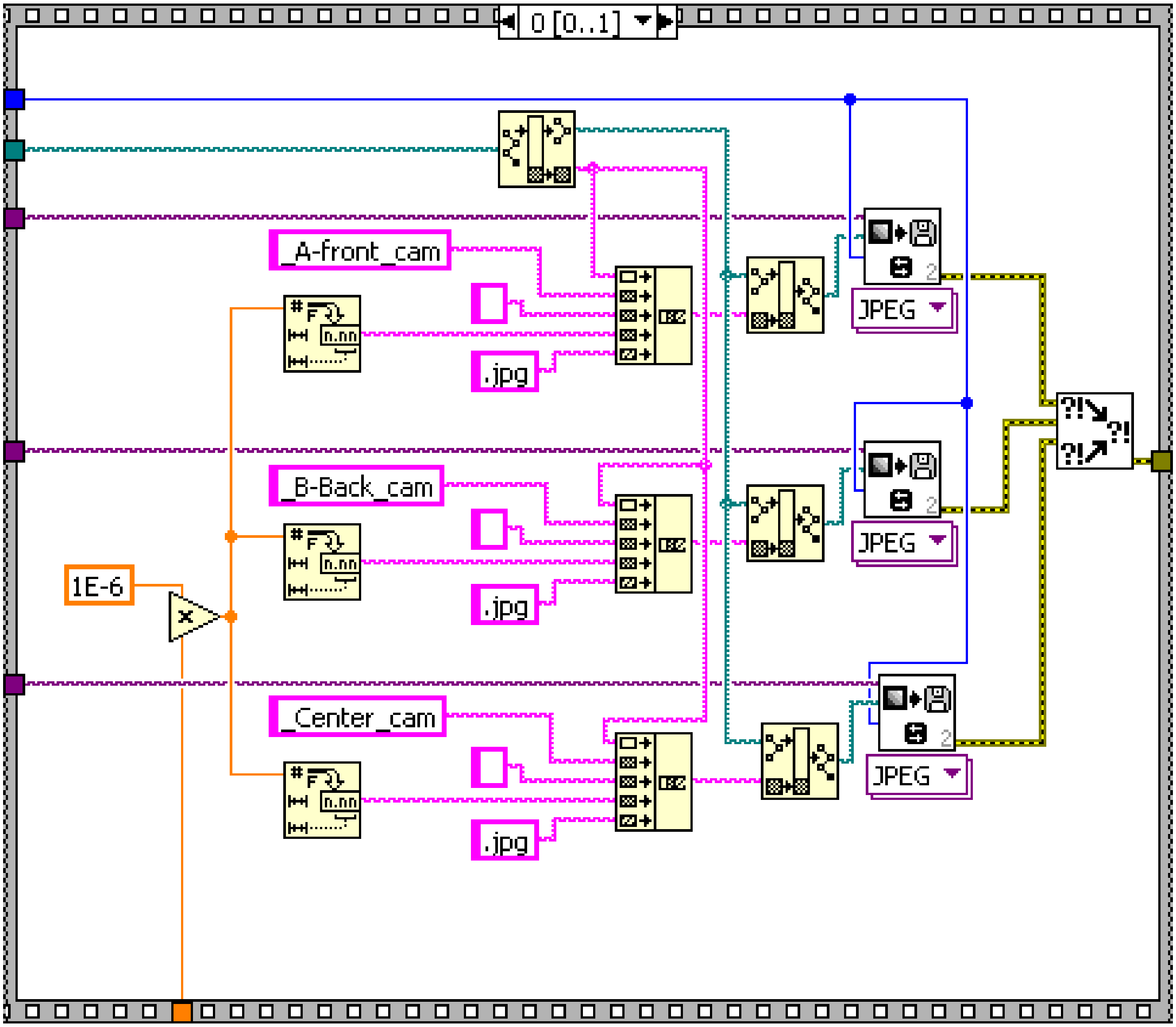
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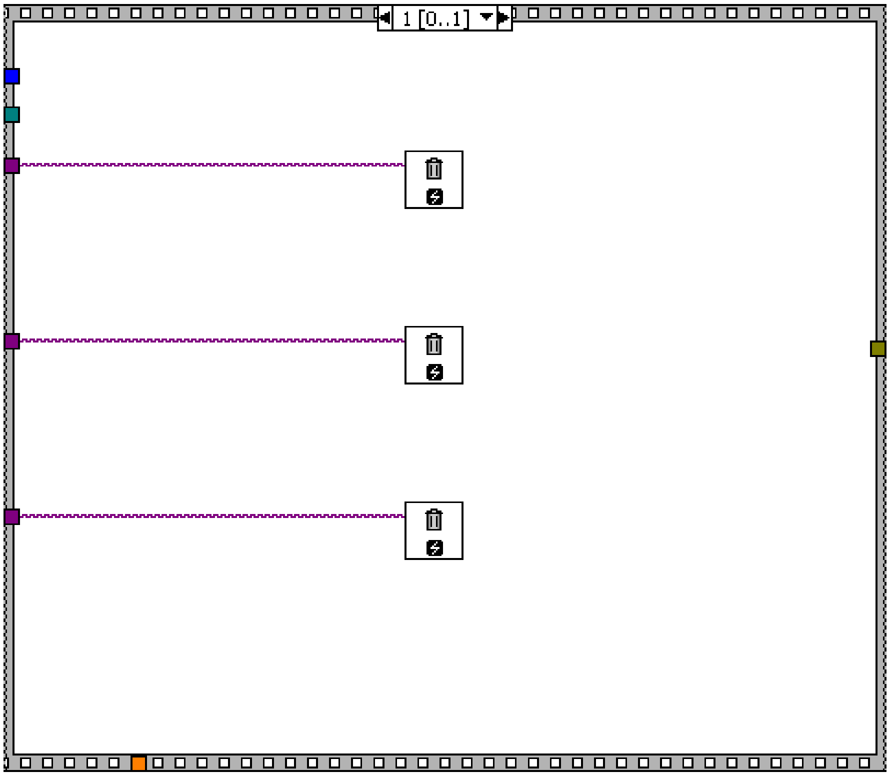
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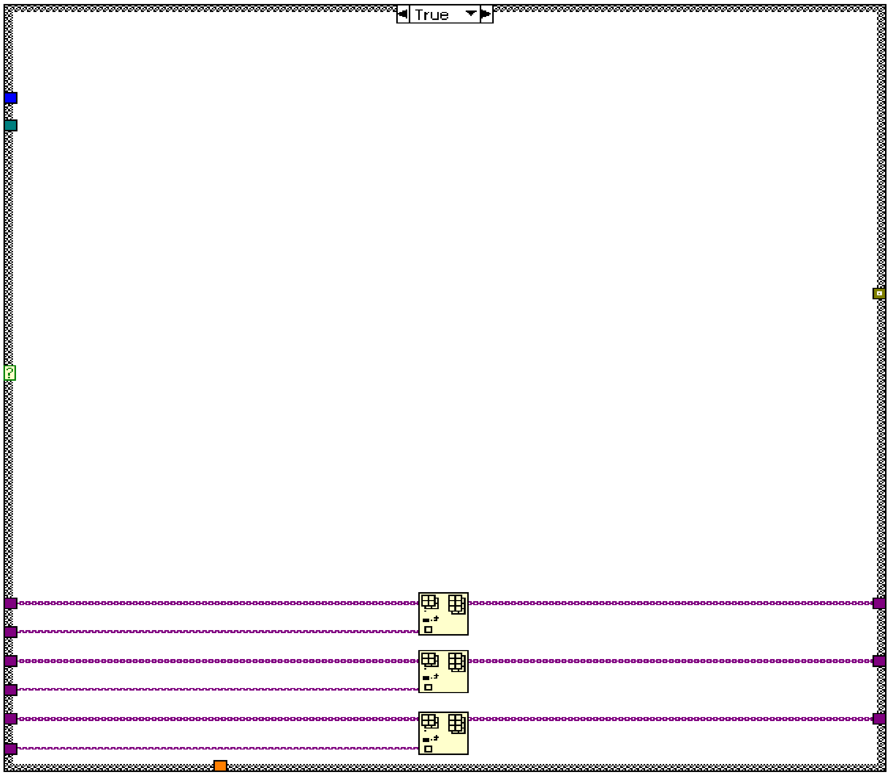
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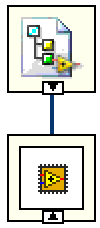
"Grab Photo.vi History"

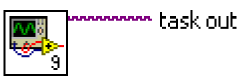
Current Revision: 19

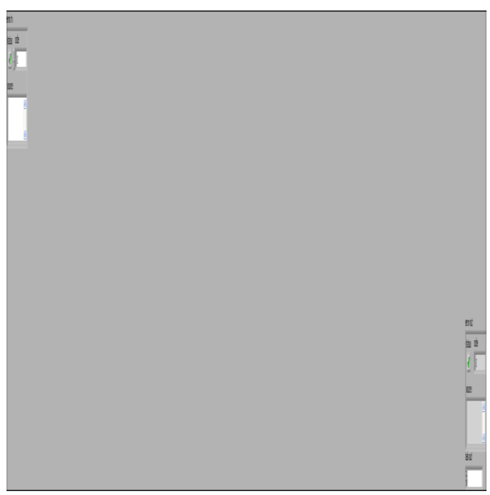
Position in Hierarchy

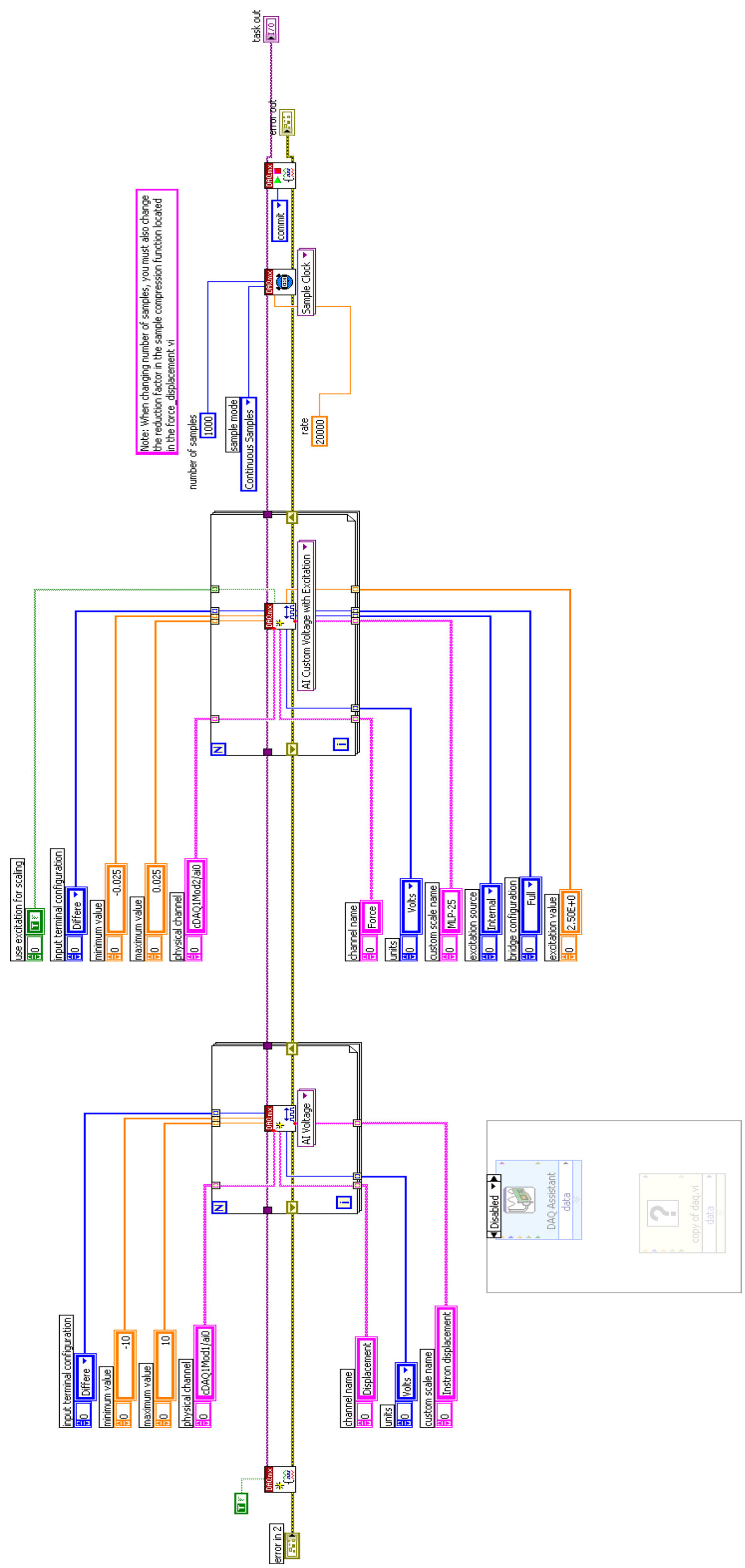


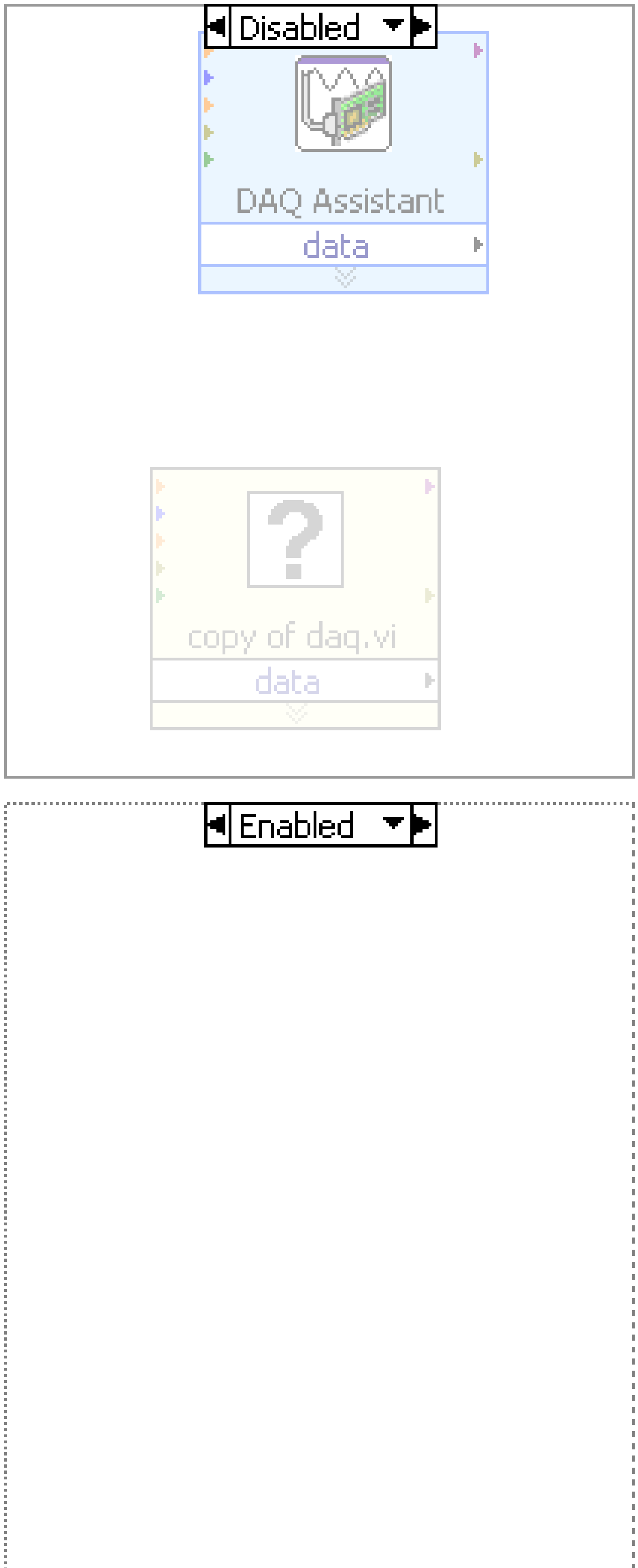
A.2.7. start_acq.vi

start_acq.vi





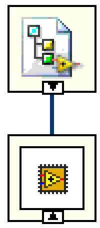

task out
error out
commit
Sample Clock
Note: When changing number of samples, you must also change the reduction factor in the sample compression function located in the force_displacement vi
number of samples
1000
sample mode
Continuous Samples
rate
20000
AI Custom Voltage with Excitation
use excitation for scaling
input terminal configuration
Differe
minimum value
-0.025
maximum value
0.025
physical channel
cDAQ1Mod2/ai0
channel name
Force
units
Volts
custom scale name
MLP-25
excitation source
Internal
bridge configuration
Full
excitation value
2.50E+0
AI Voltage
input terminal configuration
Differe
minimum value
-10
maximum value
10
physical channel
cDAQ1Mod1/ai0
channel name
Displacement
units
Volts
custom scale name
Instron displacement
Disabled
DAQ Assistant
data
copy of daq vi
data
error in 2


Disabled
DAQ Assistant
data
copy of daq.vi
data
Enabled

"start_acq.vi History"

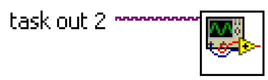
Current Revision: 31

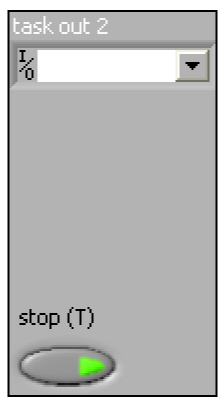
Position in Hierarchy



A.2.8 stop_acq.vi

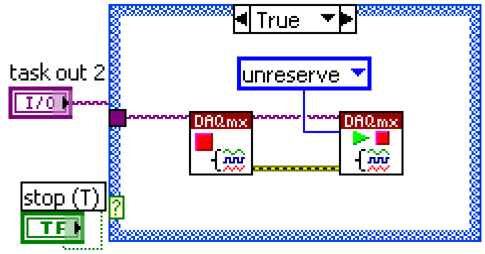
stop_acq.vi

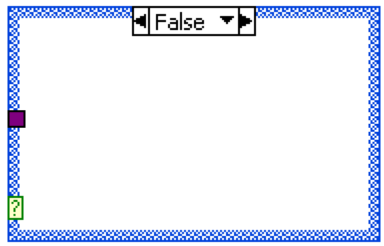


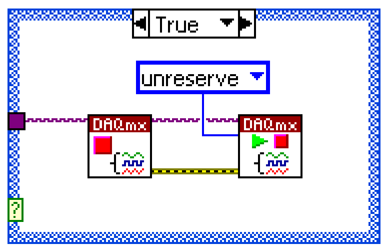


stop (T)[stop (T)]

task out 2



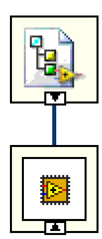




"stop_acq.vi History"

Current Revision: 1

Position in Hierarchy



APPENDIX B. TEST SETUP

B.1. Spine Preparation

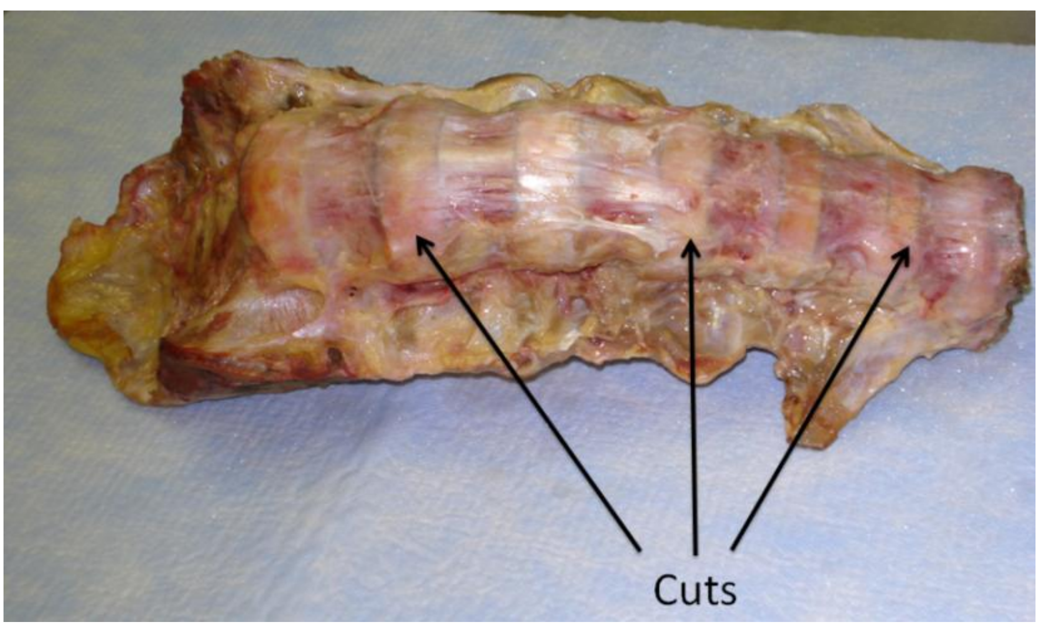
B.1.1. Separate Lumbosacral Spine for Intact L1-L2, L3-L4, L5-S1 FSU-segments

Wear gown and mask, close door before using bandsaw.

With lumbar spine still frozen, separate FSUs by cutting through every other intervertebral disc.

(e.g., for T12-Sacrum lumbar spine, cut at T12-L1 disc, L2-L3 disc, L4-L5 disc)

Clean soft tissue off of vertebral bodies for potting and dry the distal half of vertebral bodies by blotting with a paper towel.



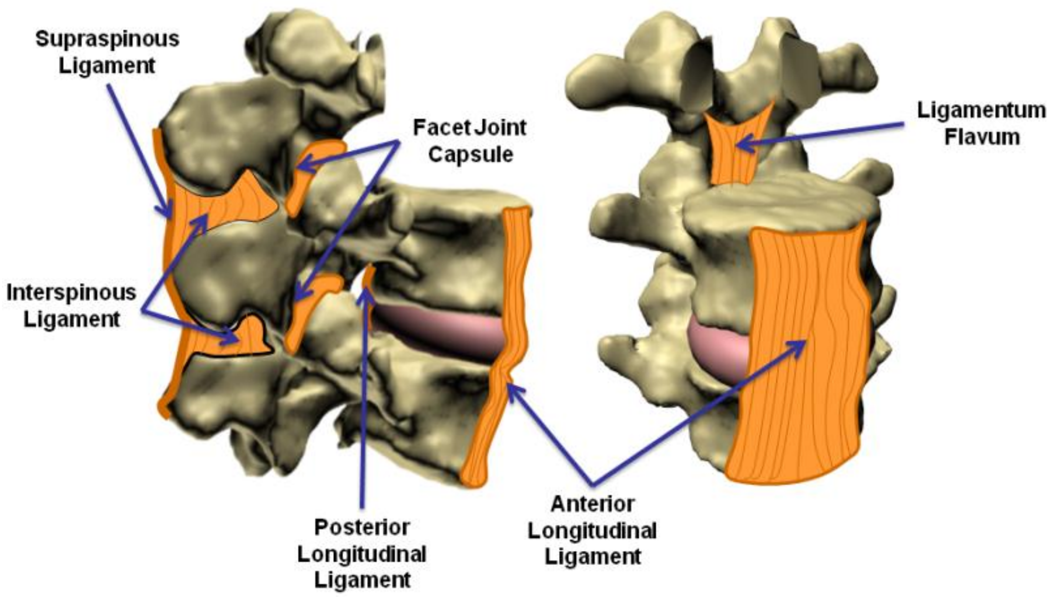
Cut locations for a dissected T12-Sacrum spine specimen

B.1.2. Dissections

Follow standard protocol for human spine dissections.

Remove muscle and fat tissue to expose ligaments and bone.

Note: Leave all ligaments intact!



.

Ligaments of a single level FSU of the lumbar spine.

B.1.3. Fixation

Line potting squares with aluminum foil

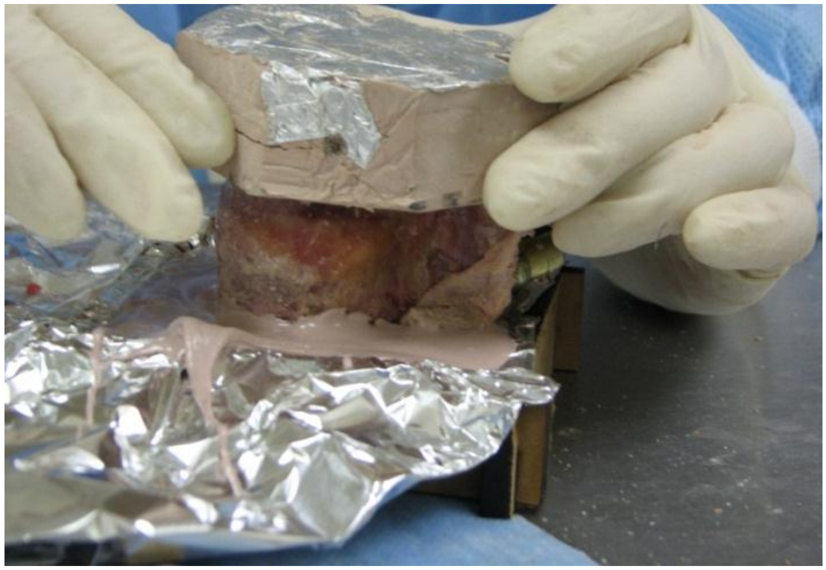
Thoroughly mix Bondo auto body filler in plastic cups.

Approximate mixture ratio from can: golf ball size of body filler with 1.25 inch strip of cream hardener.

Put mixture in potting squares.

Place superior and inferior vertebral bodies in potting squares so the disc is exposed.

Let Bondo set for 30 minutes, regularly spraying soft tissue with saline (to prevent desiccation).



Potting squares lined with aluminum foil.

B.1.4. Set Up Potting Fixtures

Inferior vertebral placement

Place inferior FSU in bottom potting fixture.

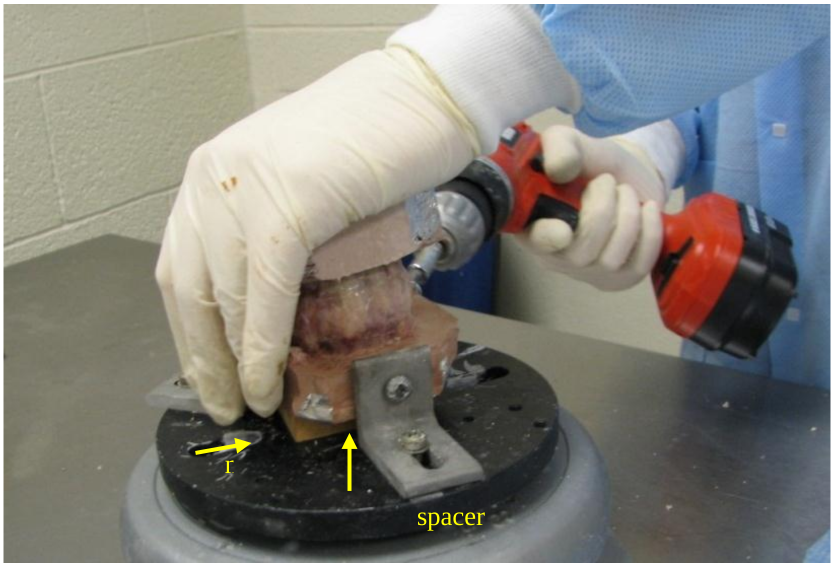
Use the acrylic spacer to elevate the FSU in the fixture.

The FSU should be set so that the posterior third is aligned with the notches for follower load.

Drill 3 screws through Bondo to vertebral body.

Attach motion tracking dots to lower potting fixture to verify rigid attachment.

Attach eye-bolts to vertebral bodies if testing a multi-FSU segment



Fixate inferior vertebra in bottom potting fixture

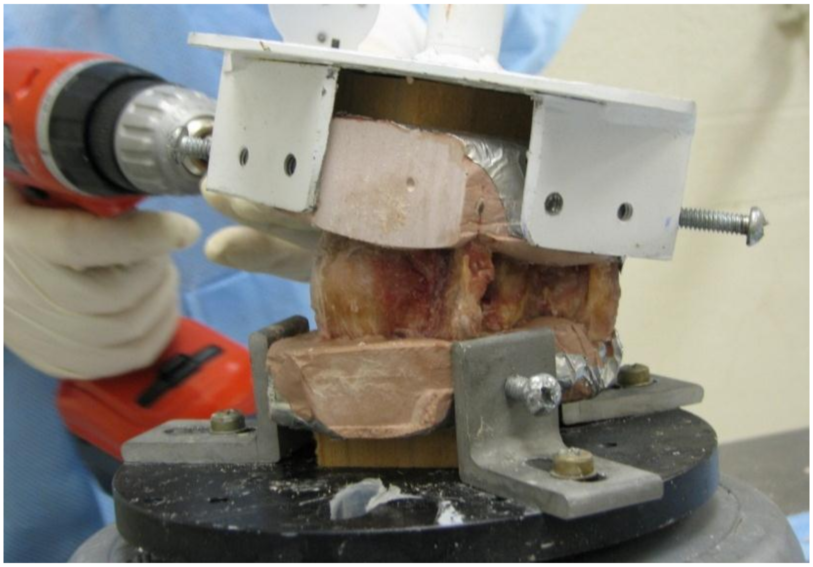
Superior vertebral placement

Place superior FSU in upper potting fixture.

Use the acrylic spacer to elevate the upper potting fixture from the FSU.

Align the center of the upper potting fixtures so the follower load acts through the approximate axis of rotation of the FSU.

Drill 4-6 screws through Bondo to vertebral body.



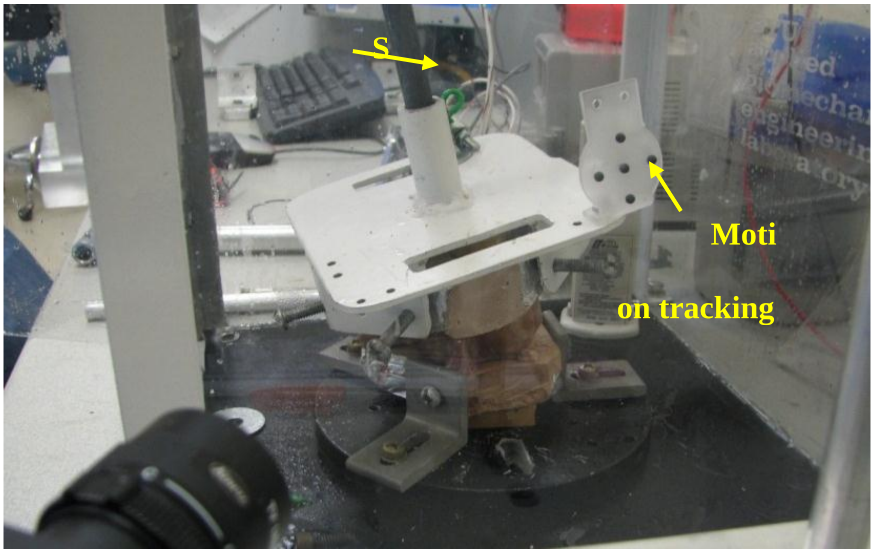
Fixate superior vertebra in upper potting fixture

Screw on plate(s) with motion tracking dots to upper potting fixture.

Place the potting fixture assembly in the environmental chamber

Align bottom fixture in chamber.

Attach upper potting fixture to shaft with Allen screws.



Insert in environmental chamber

B.1.5. Setup with Spine Tester

Follower load application

Use cable wire to attach follower load

Loop cable through cable clamp and washer

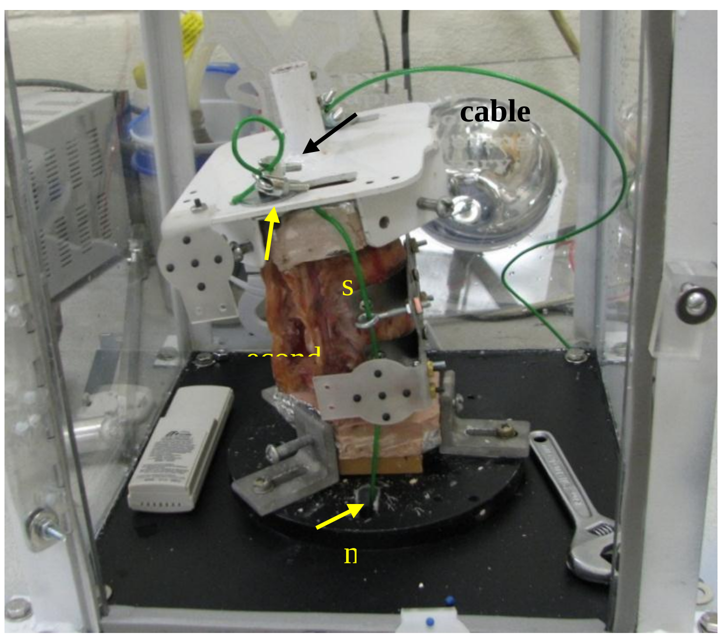
String through the top and bottom potting fixtures (and eyelets, if testing multiple FSUs), through the follower-load pulley (100lb) and back up the other side

Tighten the cable

Balance follower load on both sides

Cable should run through the center of the notch in the bottom potting fixture

Adjust load so it balances



Follower load applied on a multi-level FSU.

B.2. Testing Protocols

B.2.1. Continuous-speed Temperature/Follower-Load Tests

PRECONDITION (Be sure the calibration has already been completed!)

Orient specimen according to predetermined loading position of 1st test (e.g. FE, LB; AR is never tested first for Preconditioning of the specimen)

Verify that environmental conditions have been achieved (100% humidity & body/room temperature)

Config Tab

Verify the following settings are entered:

Desired FPS = 2

jpg capture method = “Save in HD”

Speed (deg/s) = 1

Torque Offset = 0

Control = AUTO

Auto Control = TORQUE

Loading Control = CONT

DIRECTION LIMITS

Primary

Max Angle Direction Toggle = 45

Min Angle Direction Toggle = -45

Torque Direction Toggle = 7.5

Secondary (These controls should not affect anything with PRECONDITIONING, but to prevent any problems enter these values.)

Maximum Angle Cut-off (deg) = 360

Minimum Angle Cut-off (deg) = -360

Maximum Torque Cut-off (Nm) = 8

Minimum Torque Cut-off (Nm) = -8

Main Tab:

Check and Record Temperature

Verify 100% Humidity

Motor = STOP

Display Graph = ON

Capture Data = Push to Record (you should not record data at startup)

Apply follower load

PRECONDITION SPECIMEN

START program (ctrl+R)

CREATE directory <date(yyyy.mm.dd)_specimen_FSU(L#L#)>

CREATE new folder <PRE_load_time>"

Filename = PRE_load_time.

Turn on Power Supply to Motor

Verify Position and Torque levels are acceptable

Click "**Reset Position to Zero**"

Click "**Reset**" Graph

Click "**Capture Data**" (It should read "Push to Stop")

Click **Motor** = RUN.

N = 30

Precondition until there is not a noticeable change in stiffness.

AFTER PRECONDITIONING…

STOP recording data

STOP motor

STOP program [ESC]

Turn off Power Supply to motor

Testing Direction #1 (This should be the same modal loading as the PRECONDITIONING)

Update **Config Tab**

For Loading Control = CONT

Desired FPS = 10

DIRECTION LIMITS

Primary

Max Angle Direction Toggle = 45

Min Angle Direction Toggle = - 45

Torque Direction Toggle = 7.5

Secondary

Maximum Angle Cut-off (deg) = 360

Minimum Angle Cut-off (deg) = -360

Maximum Torque Cut-off (Nm) = 8

Minimum Torque Cut-off (Nm) = -8

For Loading Control = INC

Desired FPS = 1

DIRECTION LIMITS (Primary = same as above ; Secondary = [will update automatically])

INCREMENTAL INPUTS

Primary

INC Step Length (sec) = 45 (*Acosta2008*)

INC Angle Step Interval (deg) = [anything]

INC Torque Step Intercal (Nm) = 1.5 (*Acosta2008*)

Secondary (will update automatically)

Max Angle Reverse Direction (deg) = 20

Min Angle Reverse Direction (deg) = - 20

Torque Reverse Direction (Nm) = 7.5

Main Tab

START program (ctrl+R)

CREATE directory <date(yyyy.mm.dd)_specimen_FSU(L#L#)>

CREATE new folder <temperature(BODY/ROOM)_loading(CONT/INC)_direction(FE/LB/AR)_time>

Filename = "<temperature(BODY/ROOM)_loading(CONT/INC)_direction(FE/LB/AR)_time>"

Turn on Power Supply to Motor

Verify Position and Torque levels are acceptable

Click "**Reset Position to Zero**"

Click "**Reset**" Graph

For Loading Control = CONT

Click **Motor** = RUN

Run for N=3 (Conditioning… ensure the stiffness is constant, then proceed)

Click "**Capture Data**" (It should read "Push to Stop")

Capture Data for N=2 cycles

For Loading Control = INC

Run on Loading Control = CONT for N=3 cycles

Stop Motor when Torque =~0

Update to Loading Control = INC

Click "**Capture Data**" (It should read "Push to Stop")

Click **Motor** = RUN

Immediately: Click Run INC

STOP motor

STOP recording

STOP program [ESC]

Remove Follower Load

Testing Direction #2

Update direction to FE/LB/AR

Repeat b.

Testing Direction #3

Repeat c.

Update Environmental Conditions

Repeat b, c, & d.

Proceed to continuous-speed dynamic rate tests.

B.2.2. Continuous-speed Dynamic Rate Tests

These tests are to be performed last as they may damage the soft tissue's biomechanical response.

All rate tests are to be performed in Flexion-Extension (FE).

Orient specimen orientation for Flexion-Extension.

Update **config tab** for Loading Control = CONT

START program.

CREATE new folder <SL_HIGH_time>.

Apply follower load.

START program (ctrl+R)

CREATE new folder "<test(TEMP/RATE)_environment(BODY/ROOM)_time>"

Filename = "<test(TEMP/RATE)_environment(BODY/ROOM)_time>"

START motor.

- Run for N=3 (Conditioning… ensure the stiffness is constant, then proceed)
- START Recording.
  - Record N=3.
  - Increase Rate to 2 deg/sec.
    - N=3.
  - Increase Rate by increments of 2 deg/sec.
    - N=3
    - Repeat until rate=14 deg/sec
  - Decrease Rate by increments of 2 deg/sec
    - N=3
    - Repeat until rate=1 deg/sec
- STOP recording.

STOP motor.

STOP program [ESC]

B.3. Modal Loading Tests

B.3.1. Lateral bending (LB)

The moment-arm and motor are mounted to the table.

Orient the specimen with the spinous process pointing towards the motor.

Specify new directory as “LB.”

Specify file name as “mon.dd_hhmm.”

Max-Torque cutoff = 10 Nm

Absolute Torque Limit = 7.5 Nm

B.3.2. Flexion-extension (FE)

The moment-arm and motor are mounted to the table.

Orient the specimen with spinous process pointing towards the wall.

Specify new directory as “FE.”

Specify file name as “mon.dd_hhmm.”

Max-Torque cutoff = 10 Nm.

Absolute Torque Limit = 7.5 Nm.

B.3.3. Axial rotation (AR)

The moment-arm is disconnected, and the motor is mounted above the test chamber.

Test with spinous process pointing towards the wall.

Specify new directory as “AR.”

Specify file name as “mon.dd_hhmm.”

Max-Torque cutoff = 10 Nm.

Absolute Torque Limit = 6.0 Nm.

B.4. Moving the motor

B.4.1. To Axial-Rotation

To move the motor-assembly from the horizontal table mount to the vertical chamber mount…
Unbolt the motor-assembly from the horizontal table mount.

Loosen the set screws at the universal-joint/moment-arm interface.

Loosen the set screws at the moment-arm/rod interface.

Remove moment-arm.

Lift the motor-assembly to the vertical chamber mount.

Bolt the motor-assembly to the vertical chamber mount.

Insert the rod into the universal-joint.

Tighten the set screws of the universal-joint, securing the rod.

B.4.2. To Flexion-Extension or Lateral-Bending

To move the motor-assembly from the vertical chamber mount to the horizontal table mount…

Loosen the set-screws at the universal-joint/rod interface.

Remove the rod from the universal joint.

Unbolt the motor-assembly from the vertical chamber mount.

Move the motor-assembly to the horizontal table mount.

Bolt the motor-assembly to the horizontal table mount.

Insert rod to the moment-arm, and insert moment-arm to the universal-joint.

Tighten the set screws at the moment-arm/rod interface.

Tighten the set screws at the universal-joint/moment-arm interface.

APPENDIX C. DIP-BOLTZMANN AND FLEXIBILITY PARAMETERS

Biomechanical testing was performed on approximately 27 functional spinal units (FSUs) from 8 different lumbosacral spines. 6 FSUs were used solely for the preliminary tests involving stepwise (SW) and continuous-speed (CS) comparison in flexion-extension (FE), lateral-beding (LB), and axial-rotation (AR) at both body temperature (BT) and room temperature (RT). After statistical significance was found with both SW versus CS loading-rates and BT versus RT, the remaining 21 FSUs were tested to focus on follower-load (FL) and temperature effects in FE, LB, and AR. Following these tests, CS tests were expanded to include multiple loading rates (ranging from ¼- to 14-deg/sec) only bending in FE. Some data was thrown out if there was an error in the testing procedure or if the specimen was damaged during testing.

The torque-rotation data was obtained upon analyzing the obtained images through a custom image analysis marker-tracking program. The dual inflection point (DIP) Boltzmann sigmoid equation was then fit to the data utilizing a least-squares method and the solver in Microsoft Excel 2010. The following assignments were made for the DIP-Boltzmann variables:

Ua1 = α_{1upper}	UB = B_{upper}	La2 = α_{2lower}
Um1 = m_{1upper}	LA = A_{lower}	Lm2 = m_{2lower}
Ua2 = α_{2upper}	LB = B_{lower}	
Um2 = m_{2upper}	La1 = α_{1lower}	
UA = A_{upper}	Lm1 = m_{1lower}	

The DIP-Boltzmann equation was used to calculate several commonly-used parameters to describe the FSU flexibility and torque-rotation response. Their meaning is described as follows:

ROM	The range-of-motion (ROM) is the difference between the maximum and minimum rotation.
NZ	The neutral zone (NZ) is the maximum distance between the upper and lower DIP-Boltzmann curves for any applied torque in the dataset.
UK	The stiffness of the upper curve NZ (UK) is the inverse slope of the upper DIP-Boltzmann curve at zero rotation.
LK	The stiffness of the lower curve NZ (LK) is the inverse slope of the lower DIP-Boltzmann curve at zero rotation.
K	The average NZ stiffness (K) is the average of UK and LK.
AREA	The area between the upper and lower DIP-Boltzmann curves.
H	The hysteresis (H) is the average area per degree-rotation.

All calculated parameters not used in the DIP-Boltzmann equation (NZ, UK, LK, K, Area, H) were calculated through the custom data-analysis code, which resulted in the following datasets:

Appendix C.1 Temperature & Follower-load Tests Data

- C.1.1. DIP-Boltzmann Parameters
- C.1.2 Flexibility Parameters
- C.1.3. Load-Targeted Effect DIP-Boltzmann Parameters
- C.1.4. Load-Targeted Effect Flexibility Parameters
- C.1.5. Temperature-Targeted Effect DIP-Boltzmann Parameters
- C.1.6. Temperature-Targeted Effect DIP-Boltzmann Parameters

Appendix C.2 Stepwise-loading Test Data

C.2.1. DIP-Boltzmann Parameters

C.2.2 Flexibility Parameters

C.2.3. Loading-Type-Targeted Effect DIP-Boltzmann Parameters

C.2.4. Loading-Type-Targeted Effect Flexibility Parameters

C.2.5. Temperature-Targeted Effect DIP-Boltzmann Parameters

C.2.6. Temperature-Targeted Effect DIP-Boltzmann Parameters

Appendix C.3 Dynamic-Loading Test Data

C.3.1. DIP-Boltzmann Parameters

C.3.2 Flexibility Parameters

C.3.3. Rate-Targeted Effect DIP-Boltzmann Parameters

C.3.4. Rate-Targeted Effect Flexibility Parameters

C.1. Temperature & Follower-load Tests

C.1.1. DIP-Botlzmann Parameters

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	AR	Spine1	L1L2	L	0.3336	-.5804	0.3336	-.5804	0.3384	0.6159	0.3384	0.6159	2.6821
ROOM	AR	Spine1	L1L2	L	0.3561	-.7155	0.3561	-.7155	0.3499	0.5769	0.3499	0.5769	1.7622
BODY	AR	Spine1	L1L2	nl	0.4549	-.4208	0.4549	-.4208	0.4119	0.8606	0.4119	0.8608	4.5355
ROOM	AR	Spine1	L1L2	nl	0.4104	-.2130	0.4104	-.2130	0.3792	0.9663	0.3792	0.9662	3.6149
BODY	AR	Spine1	L3L4	L	0.3554	-.5263	0.3554	-.5263	0.3685	1.0963	0.3685	1.0963	2.6759
ROOM	AR	Spine1	L3L4	L	0.3973	-.1546	0.3973	-.1546	0.3977	0.4785	0.3977	0.4785	1.9050
BODY	AR	Spine1	L5S1	L	0.2895	-.9321	0.2895	-.9321	0.2650	0.5454	0.3513	1.5542	1.4137
ROOM	AR	Spine1	L5S1	L	0.3161	-.4772	0.3162	-.4801	0.3427	1.1062	0.3668	1.4838	0.9529
ROOM	AR	Spine1	L5S1	nl	0.3796	-.6130	0.3796	-.6129	0.3799	-.4487	0.3476	0.9078	3.0002
BODY	AR	Spine2	L1L2	L	0.3550	-.9337	0.3550	-.9337	0.3508	0.5749	0.3508	0.5749	3.4276
ROOM	AR	Spine2	L1L2	L	0.3590	-.6318	0.3590	-.6318	0.3601	0.5067	0.3601	0.5067	2.8407
BODY	AR	Spine2	L1L2	nl	0.4533	-1.099	0.4533	-1.098	0.4621	0.7109	0.4622	0.7106	6.1722
ROOM	AR	Spine2	L1L2	nl	0.4815	-.7459	0.4815	-.7459	0.4820	0.4771	0.4796	0.4792	4.5935
ROOM	AR	Spine2	L3L4	L	0.4629	-.1427	0.4629	-.1427	0.4652	0.6407	0.4652	0.6407	8.1852
BODY	AR	Spine2	L3L4	nl	1.1720	-.1569	0.4458	-.3131	2.4663	0.2592	0.3921	1.6204	11.502
ROOM	AR	Spine2	L3L4	nl	0.4471	-.3608	3.5566	-.0908	0.4524	1.3238	3.0965	0.0907	11.121
BODY	AR	Spine2	L5S1	L	0.4000	-1.006	0.4000	-1.006	0.3452	1.4759	0.3452	1.4759	3.7458
ROOM	AR	Spine2	L5S1	L	0.3750	-.1018	0.3749	-.1018	0.3612	1.3541	0.3612	1.3542	3.4521
BODY	AR	Spine2	L5S1	nl	0.3728	-1.113	1.4946	0.2548	0.4064	1.0859	0.8032	0.8353	7.5175
ROOM	AR	Spine2	L5S1	nl	0.5491	-.0780	0.9791	-.0472	0.5563	0.6897	1.0828	0.5728	5.6435
BODY	AR	Spine3	L1L2	L	0.5709	-3.256	0.5320	1.7575	0.5840	3.6381	0.5806	-1.478	4.4941
ROOM	AR	Spine3	L1L2	L	0.3802	-.6671	0.3802	-.6671	0.3741	1.0643	0.3741	1.0643	2.7074
BODY	AR	Spine3	L1L2	nl	0.4385	-1.954	0.5566	0.0552	0.3551	0.7820	0.7091	0.7693	6.7372
ROOM	AR	Spine3	L1L2	nl	0.4593	-.5604	0.4593	-.5604	0.6064	2.0327	0.3929	0.0885	4.6577
BODY	AR	Spine3	L5S1	L	0.3015	0.3084	0.3010	0.2876	0.3207	1.9822	0.3209	1.9851	3.2207
ROOM	AR	Spine3	L5S1	L	0.4719	-.8558	0.1732	0.8965	0.3218	0.9958	0.3221	1.0023	1.3962
BODY	AR	Spine3	L5S1	nl	0.3292	-1.109	0.7742	-.0296	0.3803	1.2842	0.6806	0.3445	6.5537
ROOM	AR	Spine3	L5S1	nl	0.3753	-.4030	0.3772	-.4143	0.4141	0.6047	0.4194	0.6792	3.4257
BODY	AR	Spine4	L1L2	L	0.3959	-1.000	0.3959	-1.000	0.3770	0.5309	0.3770	0.5309	4.9158
ROOM	AR	Spine4	L1L2	L	0.3826	-.6918	0.3826	-.6918	0.3785	0.5096	0.3785	0.5096	3.5021

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	AR	Spine4	L1L2	nl	0.3391	-1.206	1.1275	-.4232	0.3445	1.1559	1.1957	-.0351	7.6015
ROOM	AR	Spine4	L1L2	nl	0.3797	-.4285	0.9165	-.4014	0.3606	0.4236	0.9834	0.3624	5.2641
BODY	AR	Spine4	L3L4	L	0.5508	0.6954	0.4716	-2.036	0.4283	1.4705	0.5448	-.0346	6.3673
BODY	AR	Spine4	L3L4	nl	0.4199	-.8184	3.3274	-.0343	0.4182	1.3449	3.1758	0.0560	9.7392
BODY	AR	Spine4	L5S1	L	0.3521	-.5877	0.3521	-.5877	0.3310	0.9838	0.3310	0.9838	3.0229
ROOM	AR	Spine4	L5S1	L	0.3287	-.3587	0.3287	-.3587	0.3761	0.9253	0.3761	0.9253	1.9579
BODY	AR	Spine4	L5S1	nl	0.4909	-.6194	0.4910	-.6193	0.4853	0.4540	0.4853	0.4540	5.1943
ROOM	AR	Spine4	L5S1	nl	0.4266	-.8419	0.4267	-.8418	0.4480	0.6235	0.4480	0.6235	3.4167
ROOM	AR	Spine5	L1L2	L	0.3020	-.2921	0.3020	-.2921	0.2984	0.6856	0.2984	0.6856	2.3978
BODY	AR	Spine5	L3L4	L	0.2997	0.0197	0.2997	0.0197	0.3223	0.6047	0.3223	0.6047	4.7475
ROOM	AR	Spine5	L3L4	L	0.2907	-.0412	0.2907	-.0412	0.3042	0.5497	0.3042	0.5497	4.6991
BODY	AR	Spine6	L1L2	L	0.3753	-.5565	0.3753	-.5565	0.3811	1.1849	0.3811	1.1849	6.7605
BODY	AR	Spine6	L1L2	nl	0.5471	-.5959	0.5471	-.5959	0.5621	0.5908	0.5621	0.5908	12.059
BODY	AR	Spine6	L3L4	L	0.3730	-.9403	0.3732	-.9421	0.3718	0.6518	0.3713	0.6517	8.1851
ROOM	AR	Spine6	L3L4	L	0.3848	0.1108	0.3839	0.1112	0.4184	1.3250	0.4189	1.3265	6.4915
BODY	AR	Spine7	L1L2	L	0.7115	-2.949	0.3470	-2.108	0.3321	-.5014	0.6405	-1.357	6.0531
ROOM	AR	Spine7	L1L2	L	0.4138	-2.016	0.6149	-2.168	0.3636	0.2467	0.7863	-.9069	5.3220
BODY	AR	Spine7	L1L2	nl	0.4530	-1.631	2.4616	-.4058	0.4123	0.4768	3.2030	-.0754	8.4682
ROOM	AR	Spine7	L1L2	nl	0.4509	-1.325	2.6127	-.2448	0.4584	1.0056	2.8780	0.0848	7.8002
BODY	AR	Spine7	L3L4	L	0.3394	-.8439	0.3394	-.8439	0.3836	2.2396	0.3836	2.2396	2.4225
ROOM	AR	Spine7	L3L4	L	0.3168	0.5127	0.3168	0.5127	0.2951	1.7571	0.2951	1.7571	1.8611
BODY	AR	Spine7	L5S1	L	0.4824	0.3001	0.4824	0.3001	0.4182	0.6546	0.4182	0.6546	2.3637
ROOM	AR	Spine7	L5S1	L	0.4497	0.3973	0.4497	0.3973	0.3357	0.6328	0.3357	0.6328	1.9659
BODY	AR	Spine7	L5S1	nl	0.4827	-.5268	0.4827	-.5268	0.5111	1.2539	0.5111	1.2539	4.6584
ROOM	AR	Spine7	L5S1	nl	0.5199	-.5305	0.5199	-.5305	0.4918	0.6598	0.4918	0.6598	4.6286
BODY	AR	Spine8	L1L2	L	0.5200	-1.315	0.5200	-1.315	0.4829	-.3791	0.4829	-.3791	8.5908
ROOM	AR	Spine8	L1L2	L	0.5450	-1.133	0.5450	-1.133	0.5045	-.2269	0.5044	-.2269	7.7623
BODY	AR	Spine8	L1L2	nl	0.8652	-.4384	0.8651	-.4384	0.7287	0.2985	0.7287	0.2985	11.470
ROOM	AR	Spine8	L1L2	nl	0.9015	-.4686	0.9015	-.4686	0.7625	0.3183	0.7625	0.3183	10.089
BODY	AR	Spine8	L3L4	L	0.3809	-.3370	0.3809	-.3370	0.3982	1.5839	0.3982	1.5839	4.1015
ROOM	AR	Spine8	L3L4	L	0.4327	-.3986	0.4327	-.3986	0.4262	1.0445	0.4262	1.0445	4.1891
BODY	AR	Spine8	L3L4	nl	0.4334	-.6694	0.4334	-.6694	0.4614	0.9108	0.4614	0.9108	5.7972
ROOM	AR	Spine8	L3L4	nl	0.5303	-.2936	0.5309	-.2934	0.5568	0.8736	0.5578	0.8736	6.4831
BODY	AR	Spine8	L5S1	L	0.6363	-.9616	0.1570	-2.691	0.2050	2.3470	1.1296	1.3819	4.8579
ROOM	AR	Spine8	L5S1	L	0.3544	-.3149	0.3544	-.3149	0.3588	1.6522	0.3588	1.6522	2.3833

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	AR	Spine8	L5S1	nl	0.5999	-.4912	0.4141	-.6481	0.8315	0.8479	0.3620	0.9487	6.9789
ROOM	AR	Spine8	L5S1	nl	0.4897	-.3965	0.5493	-.3713	0.3987	0.8833	0.8734	0.7960	5.3251
BODY	FE	Spine1	L1L2	L	3.5075	0.6815	0.5688	1.4041	0.5967	2.3240	3.7583	1.1815	5.4499
ROOM	FE	Spine1	L1L2	L	0.6022	0.8690	3.0064	0.0624	2.5142	0.7253	0.5883	2.1207	11.406
BODY	FE	Spine1	L1L2	nl	1.1731	0.7790	0.4178	0.1348	0.4586	1.0586	1.2012	0.8729	5.8275
ROOM	FE	Spine1	L1L2	nl	0.4568	0.6664	1.3060	1.3724	1.1911	1.4793	0.4731	1.9298	11.176
BODY	FE	Spine1	L3L4	L	0.2676	1.2942	0.2676	1.2942	0.3051	3.4759	0.3051	3.4759	3.7578
ROOM	FE	Spine1	L3L4	L	0.2578	2.8171	0.2578	2.8171	0.2839	3.9987	0.2839	3.9987	3.3543
BODY	FE	Spine1	L5S1	L	0.5207	-1.818	0.8145	3.0184	1.1503	4.5960	0.4957	2.2262	8.5246
ROOM	FE	Spine1	L5S1	L	0.4820	-1.100	1.2317	3.4850	0.4840	2.5790	1.8276	5.6387	6.5693
BODY	FE	Spine1	L5S1	nl	0.3616	-.3801	1.0736	1.3945	0.3915	1.6140	1.3158	1.1609	12.145
BODY	FE	Spine2	L1L2	L	2.9803	0.3165	0.4291	0.0579	2.9700	0.9864	0.4565	1.7498	5.6968
BODY	FE	Spine2	L1L2	nl	1.2023	0.6941	0.4022	-2.137	1.6859	0.9845	0.3646	1.4385	7.3586
ROOM	FE	Spine2	L1L2	nl	1.8616	1.0460	0.3981	-.2840	1.8236	1.4369	0.4471	1.6569	11.056
BODY	FE	Spine2	L3L4	L	0.6361	-1.044	0.9014	-1.111	0.8838	2.2967	0.8868	2.2966	5.4247
ROOM	FE	Spine2	L3L4	L	0.4491	-.2403	1.0721	-.0976	0.9414	1.5191	0.9413	1.5191	9.1586
BODY	FE	Spine2	L3L4	nl	0.7356	-.5140	0.7174	-.5208	0.8676	0.3409	0.8676	0.3409	5.5429
ROOM	FE	Spine2	L3L4	nl	3.0292	0.1990	0.5174	-.6381	2.6319	0.4456	0.5132	0.9311	10.673
BODY	FE	Spine2	L5S1	L	0.3611	0.3773	0.7530	-1.557	0.4862	1.4720	0.4812	1.4962	10.570
ROOM	FE	Spine2	L5S1	L	0.3818	0.0664	0.8307	-.0563	0.5585	2.1357	0.5619	2.1374	8.0483
BODY	FE	Spine2	L5S1	nl	0.5952	-2.037	0.8562	0.9250	0.4281	1.1158	1.1620	0.2718	14.055
ROOM	FE	Spine2	L5S1	nl	0.4912	-1.314	1.9505	0.7366	0.4720	0.9698	2.2451	0.9863	11.609
BODY	FE	Spine3	L1L2	L	0.3483	-1.321	1.7863	0.4079	0.3706	1.6975	2.2584	0.9669	9.8984
ROOM	FE	Spine3	L1L2	L	2.3898	0.9506	0.3677	-.2030	0.4421	2.2308	3.1048	1.5918	8.1706
BODY	FE	Spine3	L1L2	nl	0.6871	0.8645	0.4543	-2.079	0.7014	0.2507	0.4253	1.7283	11.102
ROOM	FE	Spine3	L1L2	nl	0.3549	-.8956	0.6442	0.1804	0.3940	2.5979	0.9277	-.0366	9.2879
ROOM	FE	Spine3	L5S1	L	5.7060	-1.640	0.6742	-1.208	4.9329	0.6233	0.6392	0.7448	16.247
BODY	FE	Spine3	L5S1	nl	0.6613	-1.564	1.8496	0.6154	1.2495	2.5872	1.6197	-.2491	11.397
ROOM	FE	Spine3	L5S1	nl	1.7024	0.7013	0.4787	-.4183	0.5204	1.4681	1.5286	1.5473	17.878
BODY	FE	Spine4	L1L2	L	0.5501	1.1213	3.5101	1.1943	2.9185	1.7679	0.6345	2.5050	10.614
ROOM	FE	Spine4	L1L2	L	0.5609	1.0764	2.7355	1.2963	0.6003	2.3781	2.8367	2.1182	8.9973
BODY	FE	Spine4	L1L2	nl	0.4263	0.1793	1.6341	1.3944	0.4962	2.0244	1.4818	1.4426	12.077
ROOM	FE	Spine4	L1L2	nl	0.4594	0.5041	1.4388	1.1716	0.5095	1.8402	1.4393	1.1714	8.9241
BODY	FE	Spine4	L3L4	L	3.9715	1.4620	0.8116	1.2270	3.8415	2.0316	0.8973	2.6637	17.097
ROOM	FE	Spine4	L3L4	L	0.7455	0.3710	9.2315	0.4101	10.150	1.0535	1.0107	1.5454	15.638

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine4	L3L4	nl	1.2245	1.3075	0.4940	0.7285	0.6436	2.8440	1.3329	0.7861	16.665
ROOM	FE	Spine4	L3L4	nl	1.5915	1.5904	0.4556	0.4733	0.6248	2.5211	1.4302	1.3291	16.605
BODY	FE	Spine4	L5S1	L	2.1810	1.3188	0.5929	1.2365	1.7128	2.0264	0.6765	2.9096	16.797
ROOM	FE	Spine4	L5S1	L	5.0281	0.1258	0.7901	0.1880	9.6043	1.3547	1.1657	1.3980	16.289
BODY	FE	Spine4	L5S1	nl	1.3040	1.2269	0.5142	0.8836	1.1705	0.7211	0.6703	2.6860	18.472
ROOM	FE	Spine4	L5S1	nl	1.5637	1.0604	0.4138	-.7525	1.4151	1.0522	0.4771	1.3179	16.773
ROOM	FE	Spine5	L1L2	L	1.3960	3.2595	1.3960	3.2595	0.6864	3.1326	0.6784	3.1317	3.2382
ROOM	FE	Spine5	L1L2	nl	0.7301	0.5947	0.7301	0.5947	0.8479	1.2772	0.8479	1.2772	3.3118
BODY	FE	Spine5	L3L4	L	0.4821	0.9794	1.6576	1.0201	1.3692	1.8444	0.5872	2.3801	18.932
ROOM	FE	Spine5	L3L4	L	0.5317	1.0143	1.6786	0.9977	0.6303	2.6448	1.5013	1.4506	19.178
BODY	FE	Spine6	L1L2	L	1.5975	-5.497	0.3727	-1.409	0.3863	-1.509	0.3863	-1.509	11.209
BODY	FE	Spine6	L1L2	nl	0.7781	-.7502	0.7781	-.7502	0.7391	-.1137	0.7391	-.1137	20.225
BODY	FE	Spine6	L3L4	L	0.2636	-2.350	0.2636	-2.350	0.2732	0.9582	0.2731	0.9582	3.9538
ROOM	FE	Spine6	L3L4	L	0.4474	0.6625	1.3685	1.6735	1.4508	2.9321	0.5656	2.8093	10.082
BODY	FE	Spine7	L1L2	L	0.3631	-.5284	1.3314	3.1060	1.5385	4.3985	0.4642	2.5006	7.3227
ROOM	FE	Spine7	L1L2	L	0.3760	0.2160	2.4295	0.2608	0.4621	2.1577	1.9333	1.4379	5.7287
BODY	FE	Spine7	L1L2	nl	0.4056	-1.027	1.5298	0.3727	0.4504	1.8098	1.7642	0.4492	11.114
ROOM	FE	Spine7	L1L2	nl	0.4455	-.2260	0.5383	-.0962	0.5223	1.4190	0.5135	1.4360	7.1975
BODY	FE	Spine7	L3L4	L	6.3448	-6.640	0.2272	-3.299	0.2391	-2.605	0.2608	-2.593	4.8210
ROOM	FE	Spine7	L3L4	L	7.6927	-6.865	0.3319	-2.932	0.2544	-2.419	4.6050	-6.588	4.5557
BODY	FE	Spine7	L5S1	L	0.5653	0.8810	0.5658	0.8812	0.6361	2.2858	0.6361	2.2858	11.656
ROOM	FE	Spine7	L5S1	L	0.4016	2.9289	0.4016	2.9289	0.5198	4.4119	0.5198	4.4119	7.0699
BODY	FE	Spine7	L5S1	nl	0.6726	1.4060	0.6726	1.4060	0.6153	2.1921	0.6153	2.1921	17.144
ROOM	FE	Spine7	L5S1	nl	0.7083	1.4465	0.7083	1.4465	0.6286	2.1448	0.6286	2.1448	16.938
BODY	FE	Spine8	L1L2	L	0.7802	-.0345	0.7805	-.0343	0.8446	1.4733	0.8463	1.4739	13.066
ROOM	FE	Spine8	L1L2	L	0.7961	-.2151	0.7961	-.2151	0.9155	1.2003	0.9154	1.2003	11.067
BODY	FE	Spine8	L1L2	nl	0.7453	-.3551	0.7448	-.3552	0.8457	0.3842	0.8457	0.3842	13.333
ROOM	FE	Spine8	L1L2	nl	0.7492	-.2570	0.7492	-.2571	0.8518	0.5298	0.8518	0.5298	11.838
BODY	FE	Spine8	L3L4	L	0.4439	0.7101	1.3542	1.7323	1.2772	2.7154	0.4924	2.4644	11.813
ROOM	FE	Spine8	L3L4	L	0.4406	1.1577	1.1652	1.4443	0.8296	2.7329	0.6921	2.6856	10.948
BODY	FE	Spine8	L3L4	nl	0.4012	-.0506	1.3265	1.4320	0.4391	2.3485	1.1889	1.4950	13.312
ROOM	FE	Spine8	L3L4	nl	0.4253	0.0613	1.5646	1.2653	0.4840	2.3001	1.3641	1.3690	12.424
ROOM	FE	Spine8	L5S1	L	0.3721	-.1910	1.4138	4.1132	1.5677	5.3027	0.3843	2.1027	6.1166
BODY	FE	Spine8	L5S1	nl	0.5466	-2.919	1.7293	0.5639	0.3770	0.2068	2.1125	0.5654	6.2613
ROOM	FE	Spine8	L5S1	nl	0.5374	-2.413	1.2015	1.3466	0.4009	1.1018	1.2193	0.8344	11.362

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	LB	Spine1	L1L2	L	1.0034	-4.863	0.6510	-.2969	0.7588	-2.073	0.5557	0.9405	5.7961
ROOM	LB	Spine1	L1L2	L	0.8164	1.1889	0.5188	-2.869	0.5326	0.7329	0.5327	0.7329	8.8147
BODY	LB	Spine1	L1L2	nl	0.8119	-.4587	0.3944	-2.067	1.4800	-.3033	0.3796	-.0107	6.5216
ROOM	LB	Spine1	L1L2	nl	8.5420	-.1854	8.5413	-.1854	7.9703	0.2105	7.9706	0.2113	10.935
BODY	LB	Spine1	L3L4	L	0.4893	-1.286	0.4893	-1.286	0.4412	1.1011	0.4412	1.1011	10.641
ROOM	LB	Spine1	L3L4	L	0.5517	-3.359	0.5519	-3.359	0.5077	-1.724	0.5077	-1.724	10.241
BODY	LB	Spine1	L5S1	L	0.9834	2.8173	0.4273	-2.691	0.3922	0.9647	1.6300	4.7591	6.1794
ROOM	LB	Spine1	L5S1	L	0.4652	0.0620	0.4975	0.1285	1.3706	3.5231	0.4415	2.2383	3.9375
BODY	LB	Spine1	L5S1	nl	0.3455	-.7747	1.2062	0.4364	0.4247	2.5406	1.1442	0.0077	11.745
BODY	LB	Spine2	L1L2	L	0.3988	-.6812	0.5705	-1.578	0.6278	-.0665	0.4022	1.7733	10.509
ROOM	LB	Spine2	L1L2	L	0.6840	-.4552	0.3868	-1.716	0.7647	1.0675	0.3569	0.5497	7.8304
ROOM	LB	Spine2	L1L2	nl	4.2752	-.3095	4.2734	-.3109	4.4534	0.4587	4.4106	0.4962	11.080
BODY	LB	Spine2	L3L4	L	0.3275	-2.231	0.3275	-2.231	0.3089	-.3928	0.3089	-.3928	3.2306
ROOM	LB	Spine2	L3L4	L	0.3763	-1.930	0.3763	-1.930	0.3717	-.0846	0.3717	-.0846	6.8890
BODY	LB	Spine2	L3L4	nl	0.6401	-1.416	0.6308	-1.420	1.3329	-1.006	0.4673	1.9182	9.1121
ROOM	LB	Spine2	L3L4	nl	1.9562	-.0284	1.9663	-.0115	1.8097	0.4714	1.8114	0.4680	13.804
BODY	LB	Spine2	L5S1	L	0.3601	-2.321	0.3601	-2.321	0.3360	0.5994	0.3360	0.5994	3.5173
ROOM	LB	Spine2	L5S1	L	0.3442	-1.277	0.3442	-1.277	0.3319	-.3575	0.3319	-.3575	1.5712
BODY	LB	Spine2	L5S1	nl	0.4628	-.8942	0.4666	-.9126	0.4127	0.9193	0.4108	0.9285	9.8461
ROOM	LB	Spine2	L5S1	nl	0.5129	-.9379	0.5130	-.9380	0.4778	0.3210	0.4778	0.3210	4.2871
BODY	LB	Spine3	L1L2	L	0.6568	-3.868	0.8583	1.6370	0.5366	-1.762	0.8041	3.4598	13.173
ROOM	LB	Spine3	L1L2	L	0.7185	-4.541	0.7226	2.6135	0.5275	-2.372	0.8411	4.6709	8.7724
BODY	LB	Spine3	L1L2	nl	0.4560	-1.950	0.7478	0.9037	0.5839	-.5850	0.5093	2.2835	15.183
ROOM	LB	Spine3	L1L2	nl	6.4842	-.7973	6.4004	0.0058	7.3714	1.4651	6.1147	0.4813	13.723
BODY	LB	Spine3	L5S1	L	0.3240	-2.042	0.3231	-2.038	0.3716	0.2967	0.3716	0.2968	1.5742
ROOM	LB	Spine3	L5S1	L	0.3526	-2.068	0.3526	-2.068	0.3542	1.0997	0.3542	1.0999	2.0814
ROOM	LB	Spine3	L5S1	nl	6.7396	-.2618	6.7252	-.2952	10.841	1.0043	12.762	0.4298	10.000
BODY	LB	Spine4	L1L2	L	0.3523	-.3579	0.9192	-1.393	0.3673	2.3728	1.2953	0.1741	12.851
ROOM	LB	Spine4	L1L2	L	1.0732	-3.478	0.4063	-.3095	0.3978	1.7787	1.0786	-1.508	8.9470
BODY	LB	Spine4	L1L2	nl	0.8453	0.3647	0.3736	-1.266	0.4477	2.7213	0.7459	-.4500	16.946
ROOM	LB	Spine4	L1L2	nl	4.3816	0.0366	4.3821	0.0366	4.3346	0.3530	4.3348	0.3526	12.036
BODY	LB	Spine4	L3L4	L	0.4488	-1.565	0.7526	0.0608	0.6743	2.1480	0.4397	0.3023	14.820
ROOM	LB	Spine4	L3L4	L	0.3274	-1.314	1.5830	0.3322	1.4729	1.5100	0.3274	0.7424	15.807
BODY	LB	Spine4	L3L4	nl	0.3884	-1.135	1.0155	0.6213	0.4141	1.0370	0.8563	0.9813	18.948
ROOM	LB	Spine4	L3L4	nl	-.1543	0.7166	0.6128	0.4408	-.1506	0.6275	0.5904	0.7781	18.267

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	LB	Spine4	L5S1	L	0.4091	-.2036	0.4091	-.2035	0.3799	1.4045	0.3799	1.4044	4.8100
BODY	LB	Spine4	L5S1	nl	1.4932	-.2381	0.3907	-1.023	1.4190	-.4724	0.4273	1.8533	12.512
ROOM	LB	Spine4	L5S1	nl	8.5200	-.4510	8.5200	-.4510	7.7669	-.0627	7.7669	-.0627	10.701
ROOM	LB	Spine5	L1L2	L	1.5717	-1.418	0.4042	-1.395	1.8547	-.6509	0.4163	-.1818	8.5804
ROOM	LB	Spine5	L1L2	nl	8.8898	-1.426	8.8898	-1.427	9.4553	-.5599	9.4553	-.5595	8.9499
BODY	LB	Spine5	L3L4	L	0.4103	-1.273	2.0282	-.4104	0.4103	1.7509	1.5782	1.2769	18.964
ROOM	LB	Spine5	L3L4	L	3.9056	-3.493	0.4934	-2.650	0.4175	-.6491	3.8137	-1.560	18.097
BODY	LB	Spine6	L3L4	L	0.3587	-.3527	0.3589	-.3536	0.3673	2.5097	0.4031	2.3751	15.890
ROOM	LB	Spine6	L3L4	L	0.3626	-.9768	0.3610	-.9854	0.3528	1.1876	0.3478	1.1893	14.112
BODY	LB	Spine7	L1L2	L	0.3273	-1.114	0.3273	-1.114	0.3287	1.6923	0.3287	1.6921	3.1196
ROOM	LB	Spine7	L1L2	L	0.2924	-.4450	0.2924	-.4446	0.3087	2.3351	0.3084	2.3265	3.9220
BODY	LB	Spine7	L1L2	nl	0.3877	-1.486	1.2348	0.9732	0.3566	1.5503	0.9525	0.9413	11.410
ROOM	LB	Spine7	L1L2	nl	1.6809	0.2831	1.7794	0.5816	1.3983	1.9443	1.3909	2.2094	10.057
BODY	LB	Spine7	L3L4	L	0.3393	-.0360	0.8242	0.2052	0.4018	2.2198	0.8777	-.1257	26.477
ROOM	LB	Spine7	L3L4	L	0.5003	-.8746	0.5112	-1.069	0.4288	0.8361	0.4264	0.9478	15.795
BODY	LB	Spine7	L5S1	L	0.4251	-1.259	0.4251	-1.259	0.3622	0.4398	0.3622	0.4398	3.3384
ROOM	LB	Spine7	L5S1	L	0.4824	-.9798	0.4824	-.9798	0.4693	0.5423	0.4693	0.5423	3.7042
BODY	LB	Spine7	L5S1	nl	0.5271	-.0349	0.5271	-.0349	0.6398	1.2204	0.6398	1.2204	11.749
ROOM	LB	Spine7	L5S1	nl	2.5253	-1.560	2.5253	-1.560	2.8930	0.0504	2.8930	0.0504	8.9942
BODY	LB	Spine8	L1L2	L	0.5398	-1.084	0.5398	-1.084	0.5800	1.0097	0.5800	1.0097	11.125
ROOM	LB	Spine8	L1L2	L	0.4483	-.5226	0.4483	-.5226	0.4526	1.4704	0.4527	1.4704	9.9027
BODY	LB	Spine8	L1L2	nl	0.6218	-.0982	0.6208	-.0983	0.6229	0.7315	0.6220	0.7316	12.871
ROOM	LB	Spine8	L1L2	nl	1.7671	-.3176	1.7671	-.3176	1.8448	0.3343	1.8448	0.3343	13.640
BODY	LB	Spine8	L3L4	L	0.3400	-.5770	0.3401	-.5768	0.3561	1.7728	0.3562	1.7727	7.4457
ROOM	LB	Spine8	L3L4	L	0.3365	-.6768	0.3364	-.6765	0.3552	1.5269	0.3554	1.5266	7.8475
BODY	LB	Spine8	L3L4	nl	0.4271	-.3761	0.5558	-.2146	0.4976	0.7738	0.4978	0.7736	14.186
ROOM	LB	Spine8	L3L4	nl	2.5798	0.0483	2.5798	0.0483	2.5595	0.8883	2.5595	0.8885	12.966
BODY	LB	Spine8	L5S1	nl	0.3429	-1.680	1.1598	-3.580	0.3474	0.5302	2.8811	-1.092	7.2381
ROOM	LB	Spine8	L5S1	nl	1.5601	-1.205	1.5602	-1.205	1.9934	0.3725	1.9958	0.3671	8.1797

C.1.2 Flexibility Parameters

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	AR	Spine1	L1L2	L	2.6821	2.7282	0.2689	0.1003	1.0172	1.1960	4.4828	4.4194	4.4511
ROOM	AR	Spine1	L1L2	L	1.7622	1.9747	0.2004	0.1137	1.1206	1.2920	6.3967	6.5098	6.4532
BODY	AR	Spine1	L1L2	nl	4.5355	5.3432	0.6433	0.1418	1.1781	1.2815	1.9496	2.1529	2.0512
ROOM	AR	Spine1	L1L2	nl	3.6149	3.8035	0.4299	0.1189	1.0522	1.1790	2.7063	2.9293	2.8178
BODY	AR	Spine1	L3L4	L	2.6759	3.8019	0.3914	0.1463	1.4208	1.6225	4.2308	4.0799	4.1553
ROOM	AR	Spine1	L3L4	L	1.9050	1.0892	0.1197	0.0628	0.5718	0.6330	5.2902	5.2857	5.2879
BODY	AR	Spine1	L5S1	L	1.4137	2.2836	0.2152	0.1522	1.6153	2.0495	9.8372	9.2964	9.5668
ROOM	AR	Spine1	L5S1	L	0.9529	1.4472	0.1455	0.1526	1.5188	1.7800	13.362	11.921	12.641
ROOM	AR	Spine1	L5S1	nl	3.0002	2.2089	0.2323	0.0774	0.7363	0.8130	3.5181	3.7271	3.6226
BODY	AR	Spine2	L1L2	L	3.4276	4.4811	0.4537	0.1324	1.3073	1.5090	3.3029	3.3429	3.3229
ROOM	AR	Spine2	L1L2	L	2.8407	2.8229	0.2897	0.1020	0.9938	1.1385	3.9330	3.9217	3.9274
BODY	AR	Spine2	L1L2	nl	6.1722	10.441	1.2604	0.2042	1.6917	1.8095	1.4463	1.4185	1.4324
ROOM	AR	Spine2	L1L2	nl	4.5935	5.3217	0.6715	0.1462	1.1585	1.2240	1.8189	1.8218	1.8204
ROOM	AR	Spine2	L3L4	L	8.1852	6.0266	0.7419	0.0906	0.7363	0.7835	1.0582	1.0529	1.0555
BODY	AR	Spine2	L3L4	nl	11.502	12.400	2.5536	0.2220	1.0780	0.6705	0.4399	0.2705	0.3552
ROOM	AR	Spine2	L3L4	nl	11.121	9.7348	1.9067	0.1715	0.8754	0.3820	0.1846	0.2221	0.2033
BODY	AR	Spine2	L5S1	L	3.7458	8.1317	0.8670	0.2315	2.1709	2.4815	2.7100	3.1404	2.9252
ROOM	AR	Spine2	L5S1	L	3.4521	4.3834	0.4618	0.1338	1.2698	1.4565	3.1055	3.2237	3.1646
BODY	AR	Spine2	L5S1	nl	7.5175	9.5566	1.5921	0.2118	1.2712	0.9620	0.6143	0.8955	0.7549
ROOM	AR	Spine2	L5S1	nl	5.6435	3.8470	0.7542	0.1336	0.6817	0.6715	0.9332	0.8708	0.9020
BODY	AR	Spine3	L1L2	L	4.4941	7.7753	0.7636	0.1699	1.7301	1.9160	2.5114	2.5356	2.5235
ROOM	AR	Spine3	L1L2	L	2.7074	4.1527	0.4384	0.1619	1.5338	1.7315	3.9137	3.9775	3.9456
BODY	AR	Spine3	L1L2	nl	6.7372	10.727	1.3495	0.2003	1.5923	1.6120	1.2815	1.1326	1.2070
ROOM	AR	Spine3	L1L2	nl	4.6577	7.2413	0.9678	0.2078	1.5547	1.8135	1.8924	1.8384	1.8654
BODY	AR	Spine3	L5S1	L	3.2207	4.4987	0.4252	0.1320	1.3968	1.6855	4.1426	3.8903	4.0165
ROOM	AR	Spine3	L5S1	L	1.3962	1.3688	0.1538	0.1102	0.9803	1.3780	9.0445	8.9281	8.9863
BODY	AR	Spine3	L5S1	nl	6.5537	8.0001	0.9110	0.1390	1.2207	1.0430	1.1330	1.1737	1.1534
ROOM	AR	Spine3	L5S1	nl	3.4257	3.2544	0.3744	0.1093	0.9500	1.0510	3.1135	2.8112	2.9624
BODY	AR	Spine4	L1L2	L	4.9158	6.7429	0.7264	0.1478	1.3717	1.5315	2.0675	2.1712	2.1193
ROOM	AR	Spine4	L1L2	L	3.5021	3.7464	0.3988	0.1139	1.0698	1.2015	2.9955	3.0280	3.0117
BODY	AR	Spine4	L1L2	nl	7.6015	9.1391	1.1885	0.1563	1.2023	0.8510	0.7348	0.7112	0.7230

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	AR	Spine4	L1L2	nl	5.2641	3.9854	0.6808	0.1293	0.7571	0.7890	1.1806	1.1393	1.1600
BODY	AR	Spine4	L3L4	L	6.3673	8.1117	0.8829	0.1387	1.2740	1.1995	1.3893	1.3410	1.3651
BODY	AR	Spine4	L3L4	nl	9.7392	10.070	1.4492	0.1488	1.0340	0.3415	0.2285	0.2480	0.2382
BODY	AR	Spine4	L5S1	L	3.0229	4.0478	0.4080	0.1350	1.3391	1.5720	3.7770	4.0171	3.8970
ROOM	AR	Spine4	L5S1	L	1.9579	2.1965	0.2372	0.1211	1.1219	1.2840	6.2405	5.4536	5.8470
BODY	AR	Spine4	L5S1	nl	5.1943	5.2934	0.6768	0.1303	1.0191	1.0735	1.5758	1.5940	1.5849
ROOM	AR	Spine4	L5S1	nl	3.4167	4.6323	0.5456	0.1597	1.3558	1.4655	2.7633	2.6313	2.6973
ROOM	AR	Spine5	L1L2	L	2.3978	1.8939	0.1759	0.0734	0.7898	0.9780	5.5325	5.5992	5.5658
BODY	AR	Spine5	L3L4	L	4.7475	2.3228	0.2447	0.0515	0.4893	0.5850	2.8133	2.6162	2.7147
ROOM	AR	Spine5	L3L4	L	4.6991	2.2568	0.2189	0.0466	0.4803	0.5905	2.9299	2.8000	2.8649
BODY	AR	Spine6	L1L2	L	6.7605	10.450	1.1037	0.1633	1.5458	1.7415	1.5879	1.5640	1.5760
BODY	AR	Spine6	L1L2	nl	12.059	13.862	1.9695	0.1633	1.1496	1.1870	0.6108	0.5944	0.6026
BODY	AR	Spine6	L3L4	L	8.1851	11.515	1.2049	0.1472	1.4068	1.5930	1.3175	1.3231	1.3203
ROOM	AR	Spine6	L3L4	L	6.4915	7.2156	0.8094	0.1247	1.1115	1.2150	1.6099	1.4781	1.5440
BODY	AR	Spine7	L1L2	L	6.0531	8.8854	1.2019	0.1986	1.4679	1.6080	1.2800	1.3909	1.3354
ROOM	AR	Spine7	L1L2	L	5.3220	8.6553	1.1319	0.2127	1.6263	1.5790	1.4823	1.3596	1.4210
BODY	AR	Spine7	L1L2	nl	8.4682	9.6641	1.9802	0.2338	1.1412	0.6165	0.3618	0.2772	0.3195
ROOM	AR	Spine7	L1L2	nl	7.8002	9.7652	1.8847	0.2416	1.2519	0.6550	0.3701	0.3362	0.3531
BODY	AR	Spine7	L3L4	L	2.4225	6.5299	0.6634	0.2739	2.6955	3.0830	4.9690	4.3964	4.6827
ROOM	AR	Spine7	L3L4	L	1.8611	1.8132	0.1822	0.0979	0.9743	1.2445	6.8029	7.3024	7.0527
BODY	AR	Spine7	L5S1	L	2.3637	0.7448	0.1399	0.0592	0.3151	0.3545	3.5117	4.0506	3.7811
ROOM	AR	Spine7	L5S1	L	1.9659	0.3282	0.1551	0.0789	0.1669	0.2355	4.5318	6.0710	5.3014
BODY	AR	Spine7	L5S1	nl	4.6584	7.9026	1.0174	0.2184	1.6964	1.7805	1.8025	1.7023	1.7524
ROOM	AR	Spine7	L5S1	nl	4.6286	5.2595	0.6968	0.1505	1.1363	1.1905	1.6727	1.7680	1.7203
BODY	AR	Spine8	L1L2	L	8.5908	7.7299	1.0263	0.1195	0.8998	0.9360	0.8988	0.9680	0.9334
ROOM	AR	Spine8	L1L2	L	7.7623	6.8065	0.9407	0.1212	0.8769	0.9065	0.9493	1.0256	0.9875
BODY	AR	Spine8	L1L2	nl	11.470	8.4069	1.7887	0.1559	0.7330	0.7370	0.4058	0.4818	0.4438
ROOM	AR	Spine8	L1L2	nl	10.089	7.9065	1.7240	0.1709	0.7837	0.7865	0.4433	0.5242	0.4837
BODY	AR	Spine8	L3L4	L	4.1015	7.0676	0.7606	0.1855	1.7232	1.9210	2.5848	2.4726	2.5287
ROOM	AR	Spine8	L3L4	L	4.1891	5.5657	0.6443	0.1538	1.3286	1.4430	2.2209	2.2550	2.2380
BODY	AR	Spine8	L3L4	nl	5.7972	8.5370	1.0209	0.1761	1.4726	1.5800	1.6058	1.5082	1.5570
ROOM	AR	Spine8	L3L4	nl	6.4831	7.3189	1.0258	0.1582	1.1289	1.1675	1.1708	1.1147	1.1428
BODY	AR	Spine8	L5S1	L	4.8579	12.713	1.6993	0.3498	2.6169	2.9585	2.2889	1.3745	1.8317
ROOM	AR	Spine8	L5S1	L	2.3833	4.0655	0.4138	0.1736	1.7058	1.9670	4.7755	4.7165	4.7460
BODY	AR	Spine8	L5S1	nl	6.9789	9.5800	1.3880	0.1989	1.3727	1.4355	1.1446	0.9762	1.0604

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	AR	Spine8	L5S1	nl	5.3251	6.1956	0.9601	0.1803	1.1635	1.2070	1.4592	1.1963	1.3277
BODY	FE	Spine1	L1L2	L	5.4499	3.7959	1.5124	0.2775	0.6965	0.5710	0.4005	0.4096	0.4051
ROOM	FE	Spine1	L1L2	L	11.406	10.665	3.3867	0.2969	0.9350	0.8195	0.2198	0.2803	0.2500
BODY	FE	Spine1	L1L2	nl	5.8275	2.7996	0.3852	0.0661	0.4804	0.3155	0.8732	0.8294	0.8513
ROOM	FE	Spine1	L1L2	nl	11.176	7.2105	1.0273	0.0919	0.6452	0.4210	0.4136	0.4342	0.4239
BODY	FE	Spine1	L3L4	L	3.7578	6.6259	0.6038	0.1607	1.7633	2.1815	4.0053	3.5140	3.7596
ROOM	FE	Spine1	L3L4	L	3.3543	3.2099	0.2890	0.0862	0.9570	1.1815	4.6355	4.2095	4.4225
BODY	FE	Spine1	L5S1	L	8.5246	23.078	2.9404	0.3449	2.7072	2.8470	1.2454	0.7303	0.9879
ROOM	FE	Spine1	L5S1	L	6.5693	18.372	2.9171	0.4440	2.7966	2.9770	1.6588	1.1745	1.4167
BODY	FE	Spine1	L5S1	nl	12.145	9.3653	1.2127	0.0999	0.7711	0.3245	0.4889	0.3896	0.4393
BODY	FE	Spine2	L1L2	L	5.6968	6.3946	1.8426	0.3234	1.1225	0.8415	0.4521	0.4653	0.4587
BODY	FE	Spine2	L1L2	nl	7.3586	12.740	1.7500	0.2378	1.7313	1.1585	0.8566	0.5532	0.7049
ROOM	FE	Spine2	L1L2	nl	11.056	12.068	2.0564	0.1860	1.0916	0.6875	0.3457	0.3258	0.3358
BODY	FE	Spine2	L3L4	L	5.4247	18.186	3.2542	0.5999	3.3524	3.3765	1.0975	0.9419	1.0197
ROOM	FE	Spine2	L3L4	L	9.1586	15.354	3.1350	0.3423	1.6765	1.6635	0.6052	0.4799	0.5426
BODY	FE	Spine2	L3L4	nl	5.5429	4.7269	0.9896	0.1785	0.8528	0.8585	1.0020	0.8391	0.9206
ROOM	FE	Spine2	L3L4	nl	10.673	9.3355	2.0125	0.1886	0.8747	0.4630	0.2258	0.2471	0.2364
BODY	FE	Spine2	L5S1	L	10.570	21.223	3.0376	0.2874	2.0078	2.3680	0.7451	0.8009	0.7730
ROOM	FE	Spine2	L5S1	L	8.0483	16.553	2.4269	0.3015	2.0567	2.1510	0.8509	0.9104	0.8807
BODY	FE	Spine2	L5S1	nl	14.055	16.549	2.3753	0.1690	1.1774	0.8140	0.5123	0.3693	0.4408
ROOM	FE	Spine2	L5S1	nl	11.609	13.978	2.3256	0.2003	1.2041	0.6945	0.3480	0.2603	0.3041
BODY	FE	Spine3	L1L2	L	9.8984	15.751	2.6989	0.2727	1.5912	1.0115	0.4364	0.3318	0.3841
ROOM	FE	Spine3	L1L2	L	8.1706	11.729	2.6736	0.3272	1.4355	0.9440	0.4128	0.3113	0.3620
BODY	FE	Spine3	L1L2	nl	11.102	16.106	1.6939	0.1526	1.4508	1.1365	0.7449	0.6696	0.7072
ROOM	FE	Spine3	L1L2	nl	9.2879	13.302	1.5285	0.1646	1.4322	0.9815	0.8836	0.7546	0.8191
ROOM	FE	Spine3	L5S1	L	16.247	34.010	10.570	0.6506	2.0933	2.0815	0.2456	0.1996	0.2226
BODY	FE	Spine3	L5S1	nl	11.397	18.574	3.2652	0.2865	1.6298	1.1075	0.4062	0.5575	0.4819
ROOM	FE	Spine3	L5S1	nl	17.878	23.656	4.9182	0.2751	1.3232	1.1005	0.2262	0.2268	0.2265
BODY	FE	Spine4	L1L2	L	10.614	10.258	3.3838	0.3188	0.9665	0.7465	0.2017	0.2406	0.2211
ROOM	FE	Spine4	L1L2	L	8.9973	9.3854	3.1676	0.3521	1.0431	0.9270	0.2965	0.2846	0.2906
BODY	FE	Spine4	L1L2	nl	12.077	10.847	1.3581	0.1124	0.8981	0.4530	0.3382	0.3410	0.3396
ROOM	FE	Spine4	L1L2	nl	8.9241	5.6987	0.7314	0.0820	0.6386	0.3390	0.4803	0.4689	0.4746
BODY	FE	Spine4	L3L4	L	17.097	17.085	6.8732	0.4020	0.9993	0.7900	0.1122	0.1224	0.1173
ROOM	FE	Spine4	L3L4	L	15.638	14.217	9.1954	0.5880	0.9091	0.8735	0.1104	0.1859	0.1482
BODY	FE	Spine4	L3L4	nl	16.665	12.968	1.6287	0.0977	0.7782	0.3235	0.2834	0.2963	0.2899

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine4	L3L4	nl	16.605	14.530	1.8759	0.1130	0.8750	0.3590	0.2467	0.2521	0.2494
BODY	FE	Spine4	L5S1	L	16.797	19.723	5.0266	0.2993	1.1742	1.0045	0.1811	0.2189	0.2000
ROOM	FE	Spine4	L5S1	L	16.289	19.866	10.175	0.6247	1.2196	1.2215	0.1478	0.0935	0.1207
BODY	FE	Spine4	L5S1	nl	18.472	11.803	1.6517	0.0894	0.6389	0.3115	0.2400	0.2799	0.2599
ROOM	FE	Spine4	L5S1	nl	16.773	16.106	1.7801	0.1061	0.9603	0.4465	0.2656	0.2540	0.2598
ROOM	FE	Spine5	L1L2	L	3.2382	-.6379	0.4485	0.1385	-.1970	-.1275	0.8895	1.8196	1.3546
ROOM	FE	Spine5	L1L2	nl	3.3118	2.2595	0.4718	0.1425	0.6823	0.6830	1.6635	1.4324	1.5479
BODY	FE	Spine5	L3L4	L	18.932	20.832	4.6743	0.2469	1.1004	1.0045	0.2042	0.2245	0.2143
ROOM	FE	Spine5	L3L4	L	19.178	19.677	4.0223	0.2097	1.0260	0.8190	0.1930	0.2147	0.2039
BODY	FE	Spine6	L1L2	L	11.209	22.562	3.6132	0.3223	2.0128	2.9000	0.7329	0.9518	0.8423
BODY	FE	Spine6	L1L2	nl	20.225	12.798	2.4551	0.1214	0.6328	0.6370	0.2552	0.2687	0.2619
BODY	FE	Spine6	L3L4	L	3.9538	9.8517	0.8645	0.2187	2.4917	3.3085	3.8894	3.7530	3.8212
ROOM	FE	Spine6	L3L4	L	10.082	16.811	3.3617	0.3334	1.6674	1.5100	0.4814	0.4147	0.4481
BODY	FE	Spine7	L1L2	L	7.3227	14.908	2.2910	0.3129	2.0358	1.7560	1.0036	0.6700	0.8368
ROOM	FE	Spine7	L1L2	L	5.7287	8.5698	2.2060	0.3851	1.4959	1.3675	0.5673	0.6656	0.6165
BODY	FE	Spine7	L1L2	nl	11.114	14.927	1.9326	0.1739	1.3431	0.6765	0.3998	0.3531	0.3765
ROOM	FE	Spine7	L1L2	nl	7.1975	10.915	1.4236	0.1978	1.5166	1.5830	1.1428	1.0848	1.1138
BODY	FE	Spine7	L3L4	L	4.8210	12.335	1.7786	0.3689	2.5586	3.7755	0.7580	3.4555	2.1067
ROOM	FE	Spine7	L3L4	L	4.5557	2.1344	0.8699	0.1910	0.4685	0.3295	0.4385	0.5443	0.4914
BODY	FE	Spine7	L5S1	L	11.656	16.059	2.4607	0.2111	1.3778	1.4050	0.6144	0.5462	0.5803
ROOM	FE	Spine7	L5S1	L	7.0699	10.362	1.3225	0.1871	1.4657	1.4825	1.4223	1.0990	1.2607
BODY	FE	Spine7	L5S1	nl	17.144	12.861	2.2179	0.1294	0.7502	0.7860	0.3485	0.3809	0.3647
ROOM	FE	Spine7	L5S1	nl	16.938	11.261	2.0797	0.1228	0.6648	0.6980	0.3348	0.3772	0.3560
BODY	FE	Spine8	L1L2	L	13.066	19.614	3.8935	0.2980	1.5012	1.5080	0.4024	0.3714	0.3869
ROOM	FE	Spine8	L1L2	L	11.067	15.618	3.2788	0.2963	1.4113	1.4155	0.4655	0.4048	0.4351
BODY	FE	Spine8	L1L2	nl	13.333	9.8039	2.0234	0.1518	0.7353	0.7400	0.4052	0.3570	0.3811
ROOM	FE	Spine8	L1L2	nl	11.838	9.2704	1.9137	0.1617	0.7831	0.7865	0.4543	0.3996	0.4269
BODY	FE	Spine8	L3L4	L	11.813	15.577	2.9781	0.2521	1.3187	1.1830	0.4023	0.3947	0.3985
ROOM	FE	Spine8	L3L4	L	10.948	15.493	2.8073	0.2564	1.4151	1.3515	0.4701	0.4894	0.4797
BODY	FE	Spine8	L3L4	nl	13.312	15.051	1.7812	0.1338	1.1306	0.6510	0.3707	0.3794	0.3750
ROOM	FE	Spine8	L3L4	nl	12.424	13.696	1.8164	0.1462	1.1024	0.6200	0.3418	0.3622	0.3520
ROOM	FE	Spine8	L5S1	L	6.1166	9.7961	1.6797	0.2746	1.6016	1.5515	1.3248	0.9805	1.1526
BODY	FE	Spine8	L5S1	nl	6.2613	9.2862	1.2510	0.1998	1.4831	0.8820	1.0179	0.5299	0.7739
ROOM	FE	Spine8	L5S1	nl	11.362	15.841	1.9358	0.1704	1.3942	0.7805	0.6607	0.4416	0.5511
BODY	LB	Spine1	L1L2	L	5.7961	11.434	1.6906	0.2917	1.9728	2.1410	1.7331	1.3452	1.5391

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	LB	Spine1	L1L2	L	8.8147	12.957	1.3399	0.1520	1.4699	1.1510	1.0115	0.8574	0.9344
BODY	LB	Spine1	L1L2	nl	6.5216	6.4793	1.1361	0.1742	0.9935	0.7575	1.0776	0.6726	0.8751
ROOM	LB	Spine1	L1L2	nl	10.935	4.3334	7.3664	0.6737	0.3963	0.3965	0.0507	0.0543	0.0525
BODY	LB	Spine1	L3L4	L	10.641	23.823	2.8976	0.2723	2.2387	2.3875	0.7845	0.8700	0.8272
ROOM	LB	Spine1	L3L4	L	10.241	15.854	2.1997	0.2148	1.5480	1.6350	0.7169	0.7792	0.7481
BODY	LB	Spine1	L5S1	L	6.1794	16.220	2.3229	0.3759	2.6248	2.9930	2.0191	1.3799	1.6995
ROOM	LB	Spine1	L5S1	L	3.9375	10.624	1.6756	0.4255	2.6982	3.0190	2.2294	1.3373	1.7833
BODY	LB	Spine1	L5S1	nl	11.745	14.916	1.4183	0.1208	1.2700	0.5470	0.4547	0.5103	0.4825
BODY	LB	Spine2	L1L2	L	10.509	19.308	2.3597	0.2245	1.8372	1.8715	0.8063	0.7902	0.7983
ROOM	LB	Spine2	L1L2	L	7.8304	13.759	1.8782	0.2399	1.7572	1.8220	0.9977	0.9357	0.9667
ROOM	LB	Spine2	L1L2	nl	11.080	8.7270	7.6941	0.6944	0.7876	0.7880	0.1013	0.0978	0.0996
BODY	LB	Spine2	L3L4	L	3.2306	4.9489	0.4732	0.1465	1.5319	1.8380	3.8030	4.0313	3.9172
ROOM	LB	Spine2	L3L4	L	6.8890	11.176	1.1773	0.1709	1.6224	1.8455	1.5555	1.5745	1.5650
BODY	LB	Spine2	L3L4	nl	9.1121	16.255	2.1501	0.2360	1.7839	1.2490	0.7016	0.6667	0.6842
ROOM	LB	Spine2	L3L4	nl	13.804	6.7597	3.1493	0.2281	0.4897	0.4895	0.1499	0.1624	0.1561
BODY	LB	Spine2	L5S1	L	3.5173	8.8301	0.8780	0.2496	2.5105	2.9200	3.2140	3.4445	3.3292
ROOM	LB	Spine2	L5S1	L	1.5712	1.2414	0.1234	0.0786	0.7901	0.9195	7.4092	7.6837	7.5465
BODY	LB	Spine2	L5S1	nl	9.8461	16.638	1.9809	0.2012	1.6898	1.8275	0.8840	0.9978	0.9409
ROOM	LB	Spine2	L5S1	nl	4.2871	5.1486	0.6707	0.1564	1.2009	1.2590	1.8310	1.9658	1.8984
BODY	LB	Spine3	L1L2	L	13.173	25.209	2.9028	0.2204	1.9136	2.1175	0.9597	0.8629	0.9113
ROOM	LB	Spine3	L1L2	L	8.7724	18.054	1.8684	0.2130	2.0580	2.6605	2.1198	1.9571	2.0384
BODY	LB	Spine3	L1L2	nl	15.183	19.039	2.0463	0.1348	1.2540	0.9450	0.5166	0.5614	0.5390
ROOM	LB	Spine3	L1L2	nl	13.723	18.787	11.185	0.8151	1.3689	1.3545	0.1174	0.1576	0.1375
BODY	LB	Spine3	L5S1	L	1.5742	3.0736	0.3226	0.2049	1.9525	2.3360	7.9446	6.9175	7.4310
ROOM	LB	Spine3	L5S1	L	2.0814	5.6748	0.5678	0.2728	2.7264	3.1680	5.5659	5.5412	5.5536
ROOM	LB	Spine3	L5S1	nl	10.000	9.9552	9.3640	0.9364	0.9955	1.0070	0.1000	0.1254	0.1127
BODY	LB	Spine4	L1L2	L	12.851	25.264	4.0863	0.3180	1.9659	1.8255	0.5241	0.4546	0.4894
ROOM	LB	Spine4	L1L2	L	8.9470	17.156	2.7946	0.3124	1.9175	1.9955	0.8207	0.8361	0.8284
BODY	LB	Spine4	L1L2	nl	16.946	23.747	2.4591	0.1451	1.4014	0.9025	0.4088	0.4826	0.4457
ROOM	LB	Spine4	L1L2	nl	12.036	3.8062	3.9905	0.3315	0.3162	0.3155	0.0783	0.0791	0.0787
BODY	LB	Spine4	L3L4	L	14.820	28.039	3.9857	0.2689	1.8920	1.9670	0.4855	0.5268	0.5062
ROOM	LB	Spine4	L3L4	L	15.807	22.947	4.6027	0.2912	1.4517	1.3505	0.3019	0.3017	0.3018
BODY	LB	Spine4	L3L4	nl	18.948	21.961	2.7643	0.1459	1.1590	0.8770	0.3232	0.3350	0.3291
ROOM	LB	Spine4	L3L4	nl	18.267	3.4693	0.5048	0.0276	0.1899	0.4825	0.9577	0.9980	0.9779
ROOM	LB	Spine4	L5S1	L	4.8100	6.8782	0.7655	0.1592	1.4300	1.6080	2.0469	2.2044	2.1256

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	LB	Spine4	L5S1	nl	12.512	14.878	1.5939	0.1274	1.1891	0.4860	0.3478	0.4057	0.3767
ROOM	LB	Spine4	L5S1	nl	10.701	4.1559	7.0444	0.6583	0.3884	0.3880	0.0513	0.0563	0.0538
ROOM	LB	Spine5	L1L2	L	8.5804	7.9860	1.9056	0.2221	0.9307	0.8560	0.4856	0.4268	0.4562
ROOM	LB	Spine5	L1L2	nl	8.9499	7.7552	8.6186	0.9630	0.8665	0.8670	0.0915	0.0860	0.0887
BODY	LB	Spine5	L3L4	L	18.964	41.993	8.8965	0.4691	2.2144	2.0660	0.2211	0.2508	0.2360
ROOM	LB	Spine5	L3L4	L	18.097	34.609	10.454	0.5777	1.9124	1.9575	0.2371	0.2733	0.2552
BODY	LB	Spine6	L3L4	L	15.890	39.049	4.0493	0.2548	2.4575	2.7925	0.7145	0.6658	0.6902
ROOM	LB	Spine6	L3L4	L	14.112	26.551	2.6959	0.1910	1.8815	2.1690	0.7913	0.8173	0.8043
BODY	LB	Spine7	L1L2	L	3.1196	7.3357	0.7056	0.2262	2.3515	2.8065	3.9733	3.9564	3.9648
ROOM	LB	Spine7	L1L2	L	3.9220	8.7846	0.8088	0.2062	2.2398	2.7760	3.5290	3.3446	3.4368
BODY	LB	Spine7	L1L2	nl	11.410	15.027	1.7234	0.1510	1.3169	0.7480	0.5016	0.5446	0.5231
ROOM	LB	Spine7	L1L2	nl	10.057	16.535	5.6317	0.5600	1.6441	1.6425	0.2588	0.3187	0.2888
BODY	LB	Spine7	L3L4	L	26.477	22.357	2.1519	0.0813	0.8444	0.4810	0.2606	0.2626	0.2616
ROOM	LB	Spine7	L3L4	L	15.795	27.614	3.4761	0.2201	1.7482	1.8640	0.5078	0.6004	0.5541
BODY	LB	Spine7	L5S1	L	3.3384	5.1416	0.5789	0.1734	1.5401	1.6990	2.8420	3.3352	3.0886
ROOM	LB	Spine7	L5S1	L	3.7042	5.3255	0.6644	0.1794	1.4377	1.5220	2.2582	2.3216	2.2899
BODY	LB	Spine7	L5S1	nl	11.749	14.476	2.2442	0.1910	1.2321	1.2555	0.6524	0.5375	0.5950
ROOM	LB	Spine7	L5S1	nl	8.9942	14.487	7.1585	0.7959	1.6107	1.6110	0.2320	0.2025	0.2172
BODY	LB	Spine8	L1L2	L	11.125	22.554	3.1779	0.2857	2.0274	2.0935	0.6816	0.6344	0.6580
ROOM	LB	Spine8	L1L2	L	9.9027	18.378	2.1862	0.2208	1.8558	1.9935	0.9134	0.9046	0.9090
BODY	LB	Spine8	L1L2	nl	12.871	10.476	1.6514	0.1283	0.8139	0.8295	0.5024	0.5015	0.5020
ROOM	LB	Spine8	L1L2	nl	13.640	8.8925	3.9062	0.2864	0.6520	0.6525	0.1699	0.1627	0.1663
BODY	LB	Spine8	L3L4	L	7.4457	15.069	1.5056	0.2022	2.0238	2.3500	1.5977	1.5255	1.5616
ROOM	LB	Spine8	L3L4	L	7.8475	14.876	1.4837	0.1891	1.8956	2.2035	1.5301	1.4487	1.4894
BODY	LB	Spine8	L3L4	nl	14.186	14.386	1.8471	0.1302	1.0141	1.0585	0.5767	0.5691	0.5729
ROOM	LB	Spine8	L3L4	nl	12.966	10.893	6.3891	0.4928	0.8401	0.8405	0.1291	0.1301	0.1296
BODY	LB	Spine8	L5S1	nl	7.2381	15.803	3.5249	0.4870	2.1834	2.2500	0.9728	0.6670	0.8199
ROOM	LB	Spine8	L5S1	nl	8.1797	12.881	4.9201	0.6015	1.5747	1.5750	0.3547	0.2775	0.3161

C.1.3. Load-Targeted Effect DIP Boltzmann Parameters

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	AR	Spine1	L1L2	nl	1.3635	0.7250	1.3635	0.7249	1.2173	1.3973	1.2172	1.3977	1.6911
ROOM	AR	Spine1	L1L2	nl	1.1526	0.2976	1.1526	0.2976	1.0837	1.6750	1.0837	1.6748	2.0513
ROOM	AR	Spine1	L5S1	nl	1.2007	1.2846	1.2004	1.2768	1.1084	-.4057	0.9476	0.6118	3.1486
BODY	AR	Spine2	L1L2	nl	1.2768	1.1765	1.2768	1.1760	1.3175	1.2367	1.3176	1.2361	1.8007
ROOM	AR	Spine2	L1L2	nl	1.3412	1.1805	1.3412	1.1805	1.3387	0.9417	1.3318	0.9457	1.6170
BODY	AR	Spine2	L5S1	nl	0.9321	1.1060	3.7366	-.2532	1.1776	0.7357	2.3271	0.5660	2.0069
ROOM	AR	Spine2	L5S1	nl	1.4645	0.7660	2.6116	0.4634	1.5402	0.5094	2.9976	0.4230	1.6348
BODY	AR	Spine3	L1L2	nl	0.7682	0.6001	1.0462	0.0314	0.6080	0.2149	1.2212	-.5204	1.4991
ROOM	AR	Spine3	L1L2	nl	1.2078	0.8401	1.2078	0.8401	1.6207	1.9099	1.0502	0.0831	1.7204
BODY	AR	Spine3	L5S1	nl	1.0918	-3.595	2.5721	-.1029	1.1858	0.6479	2.1210	0.1735	2.0349
ROOM	AR	Spine3	L5S1	nl	0.7953	0.4709	2.1783	-.4621	1.2865	0.6072	1.3023	0.6777	2.4536
BODY	AR	Spine4	L1L2	nl	0.8565	1.2060	2.8479	0.4230	0.9137	2.1771	3.1714	-.0662	1.5463
ROOM	AR	Spine4	L1L2	nl	0.9923	0.6195	2.3952	0.5802	0.9527	0.8313	2.5979	0.7111	1.5031
BODY	AR	Spine4	L5S1	nl	1.3943	1.0539	1.3945	1.0537	1.4661	0.4615	1.4661	0.4615	1.7183
ROOM	AR	Spine4	L5S1	nl	1.2979	2.3472	1.2980	2.3471	1.1912	0.6739	1.1912	0.6738	1.7451
BODY	AR	Spine6	L1L2	nl	1.4576	1.0708	1.4576	1.0708	1.4751	0.4986	1.4751	0.4986	1.7837
ROOM	AR	Spine7	L1L2	nl	1.0896	0.6572	4.2486	0.1129	1.2607	4.0758	3.6602	-.0935	1.4656
BODY	AR	Spine7	L5S1	nl	1.0007	-1.755	1.0007	-1.755	1.2223	1.9154	1.2223	1.9154	1.9708
ROOM	AR	Spine7	L5S1	nl	1.1559	-1.335	1.1559	-1.335	1.4651	1.0427	1.4651	1.0427	2.3544
BODY	AR	Spine8	L1L2	nl	1.6637	0.3333	1.6636	0.3334	1.5089	-.7872	1.5091	-.7872	1.3351
ROOM	AR	Spine8	L1L2	nl	1.6541	0.4135	1.6541	0.4135	1.5115	-1.403	1.5116	-1.403	1.2997
BODY	AR	Spine8	L3L4	nl	1.1378	1.9865	1.1378	1.9865	1.1588	0.5750	1.1588	0.5750	1.4134
ROOM	AR	Spine8	L3L4	nl	1.2254	0.7364	1.2269	0.7361	1.3065	0.8363	1.3087	0.8363	1.5476
BODY	AR	Spine8	L5S1	nl	0.9428	0.5108	2.6375	0.2408	4.0560	0.3613	0.3205	0.6865	1.4366
ROOM	AR	Spine8	L5S1	nl	1.3818	1.2593	1.5499	1.1792	1.1111	0.5346	2.4343	0.4818	2.2343
BODY	FE	Spine1	L1L2	nl	0.3345	1.1430	0.7345	0.0960	0.7686	0.4555	0.3196	0.7388	1.0693
BODY	FE	Spine1	L5S1	nl	0.6944	0.2091	1.3182	0.4620	0.3404	0.3512	2.6542	0.5215	1.4247
BODY	FE	Spine2	L1L2	nl	0.4034	2.1933	0.9373	-36.92	0.5677	0.9980	0.7986	0.8221	1.2917
BODY	FE	Spine2	L3L4	nl	1.1564	0.4922	0.7959	0.4688	0.9817	0.1484	0.9784	0.1485	1.0218
BODY	FE	Spine2	L5S1	nl	1.6480	-5.398	1.1370	-.5940	0.8805	0.7580	2.4149	0.1816	1.3297

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine2	L5S1	nl	1.2865	-19.79	2.3481	-13.09	0.8452	0.4541	3.9954	0.4614	1.4424
BODY	FE	Spine3	L1L2	nl	1.9724	-.6545	0.2543	-5.097	1.8926	0.1477	0.1883	1.7874	1.1216
ROOM	FE	Spine3	L1L2	nl	0.1485	-.9421	1.7522	-.8886	0.8913	1.1646	0.2988	-.0230	1.1368
ROOM	FE	Spine3	L5S1	nl	0.2983	-.4277	0.7100	0.3462	0.1055	2.3555	2.3914	2.0775	1.1004
BODY	FE	Spine4	L1L2	nl	0.7750	0.1599	0.4655	1.1675	0.1700	1.1451	2.3356	0.5759	1.1379
ROOM	FE	Spine4	L1L2	nl	0.8190	0.4684	0.5260	0.9038	0.8487	0.7738	0.5074	0.5530	0.9919
BODY	FE	Spine4	L3L4	nl	0.3083	0.8943	0.6087	0.5937	0.1675	1.3999	1.4854	0.2951	0.9747
ROOM	FE	Spine4	L3L4	nl	2.1349	4.2865	0.0494	1.1543	0.0616	2.3931	1.4152	0.8601	1.0619
BODY	FE	Spine4	L5S1	nl	0.5979	0.9303	0.8673	0.7146	0.6834	0.3558	0.9908	0.9231	1.0998
ROOM	FE	Spine5	L1L2	nl	0.5230	0.1825	0.5230	0.1825	1.2352	0.4077	1.2498	0.4078	1.0227
BODY	FE	Spine6	L1L2	nl	0.4870	0.1365	2.0878	0.5324	1.9134	0.0753	1.9134	0.0753	1.8043
BODY	FE	Spine7	L1L2	nl	1.1171	1.9443	1.1490	0.1200	0.2928	0.4115	3.8002	0.1796	1.5178
ROOM	FE	Spine7	L1L2	nl	1.1846	-1.046	0.2216	-.3687	1.1304	0.6576	0.2656	0.9987	1.2564
BODY	FE	Spine7	L5S1	nl	1.1898	1.5959	1.1889	1.5956	0.9672	0.9590	0.9672	0.9590	1.4709
ROOM	FE	Spine7	L5S1	nl	1.7636	0.4939	1.7636	0.4939	1.2094	0.4861	1.2094	0.4861	2.3958
ROOM	FE	Spine8	L1L2	nl	0.9411	1.1948	0.9410	1.1949	0.9304	0.4414	0.9305	0.4414	1.0697
BODY	FE	Spine8	L3L4	nl	0.9038	-.0713	0.9795	0.8266	0.3438	0.8649	2.4145	0.6066	1.1269
ROOM	FE	Spine8	L3L4	nl	0.9653	0.0530	1.3428	0.8761	0.5834	0.8417	1.9708	0.5098	1.1349
BODY	LB	Spine1	L5S1	nl	0.3514	-.2750	2.8231	-.1622	1.0828	2.6335	0.7020	0.0016	1.9007
BODY	LB	Spine2	L3L4	nl	1.9547	0.6348	1.9261	0.6366	4.3145	2.5618	1.5126	-4.883	2.8205
ROOM	LB	Spine2	L3L4	nl	5.1986	0.0147	5.2256	0.0060	4.8683	-5.571	4.8728	-5.530	2.0038
BODY	LB	Spine2	L5S1	nl	1.2852	0.3852	1.2960	0.3931	1.2284	1.5337	1.2227	1.5490	2.7993
ROOM	LB	Spine2	L5S1	nl	1.4903	0.7344	1.4907	0.7345	1.4397	-.8979	1.4397	-.8978	2.7286
BODY	LB	Spine3	L1L2	nl	0.6943	0.5040	0.8714	0.5521	1.0883	0.3321	0.6334	0.6600	1.1526
BODY	LB	Spine4	L1L2	nl	2.3997	-1.019	0.4065	0.9095	1.2191	1.1469	0.5758	-2.584	1.3186
ROOM	LB	Spine4	L3L4	nl	-.4712	-.5453	0.3871	1.3272	-.1023	0.4155	1.8035	1.0480	1.1557
BODY	LB	Spine7	L1L2	nl	1.1844	1.3342	3.7723	-.8733	1.0846	0.9161	2.8975	0.5563	3.6576
BODY	LB	Spine7	L5S1	nl	1.2400	0.0278	1.2400	0.0278	1.7662	2.7748	1.7662	2.7748	3.5195
BODY	LB	Spine8	L1L2	nl	1.1518	0.0906	1.1500	0.0907	1.0740	0.7244	1.0724	0.7245	1.1570
ROOM	LB	Spine8	L1L2	nl	3.9421	0.6077	3.9419	0.6077	4.0759	0.2274	4.0755	0.2274	1.3774
BODY	LB	Spine8	L3L4	nl	1.2561	0.6519	1.6342	0.3720	1.3972	0.4365	1.3976	0.4364	1.9053

C.1.4 Load-Targeted Effect Flexibility Parameters

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	AR	Spine1	L1L2	nl	1.6911	1.9585	2.3920	1.4145	1.1581	1.0715	0.4349	0.4871	0.4608
ROOM	AR	Spine1	L1L2	nl	2.0513	1.9261	2.1449	1.0456	0.9390	0.9125	0.4231	0.4500	0.4367
ROOM	AR	Spine1	L5S1	nl	3.1486	1.5263	1.5973	0.5073	0.4847	0.4567	0.2633	0.3126	0.2866
BODY	AR	Spine2	L1L2	nl	1.8007	2.3301	2.7777	1.5426	1.2940	1.1991	0.4379	0.4243	0.4311
ROOM	AR	Spine2	L1L2	nl	1.6170	1.8852	2.3178	1.4334	1.1658	1.0751	0.4625	0.4645	0.4635
BODY	AR	Spine2	L5S1	nl	2.0069	1.1752	1.8364	0.9150	0.5856	0.3877	0.2267	0.2851	0.2581
ROOM	AR	Spine2	L5S1	nl	1.6348	0.8776	1.6333	0.9991	0.5368	0.4610	0.3005	0.2701	0.2850
BODY	AR	Spine3	L1L2	nl	1.4991	1.3797	1.7673	1.1789	0.9203	0.8413	0.5103	0.4467	0.4783
ROOM	AR	Spine3	L1L2	nl	1.7204	1.7437	2.2078	1.2833	1.0136	1.0474	0.4835	0.4622	0.4728
BODY	AR	Spine3	L5S1	nl	2.0349	1.7783	2.1427	1.0530	0.8739	0.6188	0.2735	0.3017	0.2872
ROOM	AR	Spine3	L5S1	nl	2.4536	2.3776	2.4343	0.9921	0.9691	0.7627	0.3442	0.3149	0.3297
BODY	AR	Spine4	L1L2	nl	1.5463	1.3554	1.6361	1.0581	0.8765	0.5557	0.3554	0.3276	0.3411
ROOM	AR	Spine4	L1L2	nl	1.5031	1.0638	1.7073	1.1358	0.7077	0.6567	0.3941	0.3763	0.3852
BODY	AR	Spine4	L5S1	nl	1.7183	1.3077	1.6586	0.9653	0.7610	0.6829	0.4172	0.3968	0.4067
ROOM	AR	Spine4	L5S1	nl	1.7451	2.1090	2.3002	1.3181	1.2085	1.1414	0.4428	0.4825	0.4613
BODY	AR	Spine6	L1L2	nl	1.7837	1.3265	1.7844	1.0004	0.7437	0.6816	0.3846	0.3801	0.3824
ROOM	AR	Spine7	L1L2	nl	1.4656	1.1282	1.6650	1.1360	0.7698	0.4148	0.2497	0.2473	0.2485
BODY	AR	Spine7	L5S1	nl	1.9708	10.610	7.2699	3.6887	5.3834	5.0226	0.5133	0.4203	0.4635
ROOM	AR	Spine7	L5S1	nl	2.3544	16.027	4.4913	1.9076	6.8071	5.0552	0.3691	0.2912	0.3245
BODY	AR	Spine8	L1L2	nl	1.3351	1.0876	1.7429	1.3055	0.8146	0.7874	0.4515	0.4978	0.4755
ROOM	AR	Spine8	L1L2	nl	1.2997	1.1616	1.8326	1.4100	0.8938	0.8676	0.4670	0.5111	0.4899
BODY	AR	Spine8	L3L4	nl	1.4134	1.2079	1.3421	0.9495	0.8546	0.8225	0.6212	0.6100	0.6157
ROOM	AR	Spine8	L3L4	nl	1.5476	1.3150	1.5921	1.0287	0.8497	0.8091	0.5272	0.4943	0.5106
BODY	AR	Spine8	L5S1	nl	1.4366	0.7536	0.8168	0.5686	0.5245	0.4852	0.5001	0.7102	0.5789
ROOM	AR	Spine8	L5S1	nl	2.2343	1.5239	2.3201	1.0384	0.6821	0.6136	0.3056	0.2536	0.2798
BODY	FE	Spine1	L1L2	nl	1.0693	0.7376	0.2547	0.2382	0.6898	0.5525	2.1801	2.0251	2.1017
BODY	FE	Spine1	L5S1	nl	1.4247	0.4058	0.4124	0.2895	0.2848	0.1140	0.3926	0.5335	0.4447
BODY	FE	Spine2	L1L2	nl	1.2917	1.9923	0.9497	0.7352	1.5424	1.3767	1.8950	1.1889	1.5369
BODY	FE	Spine2	L3L4	nl	1.0218	0.2599	0.3041	0.2976	0.2544	0.2543	0.9130	0.8909	0.9028
BODY	FE	Spine2	L5S1	nl	1.3297	0.7798	0.7820	0.5881	0.5864	0.3438	0.6876	0.4611	0.5703

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine2	L5S1	nl	1.4424	0.8445	0.9583	0.6644	0.5855	0.3229	0.4089	0.2859	0.3453
BODY	FE	Spine3	L1L2	nl	1.1216	1.0226	0.6276	0.5596	0.9117	1.1236	1.7068	2.0178	1.8411
ROOM	FE	Spine3	L1L2	nl	1.1368	1.1342	0.5717	0.5029	0.9977	1.0397	2.1406	2.4242	2.2625
ROOM	FE	Spine3	L5S1	nl	1.1004	0.6956	0.4653	0.4228	0.6321	0.5287	0.9209	1.1367	1.0176
BODY	FE	Spine4	L1L2	nl	1.1379	1.0574	0.4013	0.3527	0.9292	0.6068	1.6768	1.4175	1.5357
ROOM	FE	Spine4	L1L2	nl	0.9919	0.6072	0.2309	0.2328	0.6122	0.3657	1.6198	1.6473	1.6333
BODY	FE	Spine4	L3L4	nl	0.9747	0.7590	0.2370	0.2431	0.7787	0.4095	2.5263	2.4216	2.4717
ROOM	FE	Spine4	L3L4	nl	1.0619	1.0220	0.2040	0.1921	0.9625	0.4110	2.2342	1.3562	1.6834
BODY	FE	Spine4	L5S1	nl	1.0998	0.5984	0.3286	0.2988	0.5442	0.3101	1.3254	1.2786	1.2998
ROOM	FE	Spine5	L1L2	nl	1.0227	-3.542	1.0521	1.0287	-3.464	-5.357	1.8701	0.7872	1.1428
BODY	FE	Spine6	L1L2	nl	1.8043	0.5673	0.6795	0.3766	0.3144	0.2197	0.3482	0.2823	0.3110
BODY	FE	Spine7	L1L2	nl	1.5178	1.0013	0.8436	0.5558	0.6597	0.3853	0.3984	0.5271	0.4499
ROOM	FE	Spine7	L1L2	nl	1.2564	1.2737	0.6453	0.5136	1.0138	1.1576	2.0145	1.6296	1.8067
BODY	FE	Spine7	L5S1	nl	1.4709	0.8009	0.9013	0.6128	0.5445	0.5594	0.5672	0.6975	0.6285
ROOM	FE	Spine7	L5S1	nl	2.3958	1.0867	1.5725	0.6563	0.4536	0.4708	0.2354	0.3432	0.2824
ROOM	FE	Spine8	L1L2	nl	1.0697	0.5936	0.5836	0.5456	0.5549	0.5556	0.9759	0.9870	0.9811
BODY	FE	Spine8	L3L4	nl	1.1269	0.9662	0.5981	0.5307	0.8574	0.5503	0.9214	0.9611	0.9410
ROOM	FE	Spine8	L3L4	nl	1.1349	0.8840	0.6470	0.5701	0.7790	0.4587	0.7270	0.7400	0.7337
BODY	LB	Spine1	L5S1	nl	1.9007	0.9197	0.6106	0.3212	0.4839	0.1828	0.2252	0.3698	0.2839
BODY	LB	Spine2	L3L4	nl	2.8205	3.2845	4.5434	1.6108	1.1645	0.6795	0.1845	0.1654	0.1747
ROOM	LB	Spine2	L3L4	nl	2.0038	0.6048	2.6750	1.3350	0.3018	0.2652	0.0964	0.1031	0.0998
BODY	LB	Spine2	L5S1	nl	2.7993	1.8842	2.2562	0.8060	0.6731	0.6259	0.2751	0.2897	0.2826
ROOM	LB	Spine2	L5S1	nl	2.7286	4.1473	5.4329	1.9911	1.5199	1.3692	0.2471	0.2558	0.2516
BODY	LB	Spine3	L1L2	nl	1.1526	0.7553	0.7049	0.6116	0.6553	0.4463	0.5384	0.6506	0.5915
BODY	LB	Spine4	L1L2	nl	1.3186	0.9399	0.6018	0.4564	0.7128	0.4944	0.7800	1.0616	0.9108
ROOM	LB	Spine4	L3L4	nl	1.1557	0.1512	0.1097	0.0949	0.1308	0.3573	3.1725	3.3078	3.2401
BODY	LB	Spine7	L1L2	nl	3.6576	2.0484	2.4426	0.6678	0.5601	0.2665	0.1262	0.1377	0.1319
BODY	LB	Spine7	L5S1	nl	3.5195	2.8155	3.8767	1.1015	0.8000	0.7390	0.2295	0.1612	0.1926
BODY	LB	Spine8	L1L2	nl	1.1570	0.4645	0.5196	0.4491	0.4014	0.3962	0.7371	0.7905	0.7628
ROOM	LB	Spine8	L1L2	nl	1.3774	0.4839	1.7867	1.2972	0.3513	0.3273	0.1860	0.1799	0.1829
BODY	LB	Spine8	L3L4	nl	1.9053	0.9547	1.2269	0.6439	0.5011	0.4504	0.3610	0.3731	0.3669

C.1.5. Temperature-Targeted Effect DIP Boltzmann Parameters

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	AR	Spine1	L1L2	L	1.0675	1.2328	1.0675	1.2328	1.0341	0.9368	1.0341	0.9367	0.6570
ROOM	AR	Spine1	L1L2	nl	0.9023	0.5061	0.9023	0.5061	0.9206	1.1229	0.9206	1.1225	0.7970
ROOM	AR	Spine1	L3L4	L	1.1180	0.2938	1.1180	0.2938	1.0791	0.4365	1.0791	0.4365	0.7119
ROOM	AR	Spine1	L5S1	L	1.0922	0.5120	1.0924	0.5150	1.2932	2.0282	1.0441	0.9547	0.6740
ROOM	AR	Spine2	L1L2	L	1.0113	0.6767	1.0113	0.6767	1.0265	0.8814	1.0265	0.8814	0.8288
ROOM	AR	Spine2	L1L2	nl	1.0624	0.6790	1.0624	0.6793	1.0430	0.6711	1.0376	0.6743	0.7442
ROOM	AR	Spine2	L5S1	L	0.9375	0.1012	0.9374	0.1012	1.0465	0.9175	1.0465	0.9176	0.9216
ROOM	AR	Spine2	L5S1	nl	1.4729	0.0701	0.6551	-.1852	1.3687	0.6352	1.3481	0.6858	0.7507
ROOM	AR	Spine3	L1L2	L	0.6661	0.2049	0.7147	-.3795	0.6406	0.2925	0.6444	-.7200	0.6024
ROOM	AR	Spine3	L1L2	nl	1.0473	0.2868	0.8252	-10.15	1.7078	2.5995	0.5542	0.1150	0.6913
ROOM	AR	Spine3	L5S1	L	1.5652	-2.775	0.5753	3.1170	1.0037	0.5024	1.0037	0.5049	0.4335
ROOM	AR	Spine4	L1L2	L	0.9665	0.6916	0.9665	0.6916	1.0040	0.9598	1.0040	0.9598	0.7124
ROOM	AR	Spine4	L1L2	nl	1.1197	0.3553	0.8128	0.9486	1.0469	0.3665	0.8225	-10.31	0.6925
ROOM	AR	Spine4	L5S1	L	0.9336	0.6103	0.9336	0.6103	1.1362	0.9405	1.1362	0.9405	0.6477
ROOM	AR	Spine4	L5S1	nl	0.8690	1.3592	0.8690	1.3594	0.9231	1.3734	0.9232	1.3734	0.6578
ROOM	AR	Spine5	L3L4	L	0.9700	-2.095	0.9700	-2.095	0.9438	0.9090	0.9439	0.9090	0.9898
ROOM	AR	Spine6	L3L4	L	1.0316	-.1178	1.0286	-.1180	1.1252	2.0330	1.1284	2.0354	0.7931
ROOM	AR	Spine7	L1L2	L	0.5816	0.6837	1.7724	1.0288	1.0950	-.4921	1.2277	0.6685	0.8792
ROOM	AR	Spine7	L1L2	nl	0.9954	0.8123	1.0614	0.6032	1.1119	2.1089	0.8985	-1.125	0.9211
ROOM	AR	Spine7	L3L4	L	0.9333	-.6076	0.9333	-.6076	0.7693	0.7846	0.7692	0.7846	0.7682
ROOM	AR	Spine7	L5S1	L	0.9324	1.3239	0.9324	1.3239	0.8028	0.9667	0.8028	0.9667	0.8317
ROOM	AR	Spine7	L5S1	nl	1.0769	1.0069	1.0769	1.0069	0.9622	0.5262	0.9622	0.5262	0.9936
ROOM	AR	Spine8	L1L2	L	1.0481	0.8618	1.0480	0.8618	1.0446	0.5984	1.0447	0.5984	0.9036
ROOM	AR	Spine8	L1L2	nl	1.0420	1.0689	1.0421	1.0689	1.0464	1.0664	1.0464	1.0664	0.8796
ROOM	AR	Spine8	L3L4	L	1.1361	1.1830	1.1361	1.1830	1.0704	0.6595	1.0704	0.6595	1.0213
ROOM	AR	Spine8	L3L4	nl	1.2236	0.4386	1.2251	0.4384	1.2068	0.9591	1.2089	0.9592	1.1183
ROOM	AR	Spine8	L5S1	L	0.5569	0.3275	2.2571	0.1170	1.7501	0.7039	0.3176	1.1956	0.4906
ROOM	AR	Spine8	L5S1	nl	0.8163	0.8074	1.3264	0.5730	0.4795	1.0417	2.4127	0.8391	0.7630

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine1	L1L2	L	0.1717	1.2750	5.2852	0.0444	4.2136	0.3121	0.1565	1.7949	2.0929
ROOM	FE	Spine1	L3L4	L	0.9631	2.1767	0.9631	2.1767	0.9305	1.1504	0.9305	1.1504	0.8926
ROOM	FE	Spine1	L5S1	L	0.9257	0.6049	1.5122	1.1546	0.4207	0.5611	3.6865	2.5329	0.7706
ROOM	FE	Spine2	L1L2	nl	1.5484	1.5068	0.9898	0.1329	1.0817	1.4595	1.2263	1.1518	1.5025
ROOM	FE	Spine2	L3L4	L	0.7060	0.2301	1.1895	0.0878	1.0652	0.6614	1.0615	0.6615	1.6883
ROOM	FE	Spine2	L3L4	nl	4.1177	-.3871	0.7212	1.2251	3.0335	1.3070	0.5916	2.7312	1.9255
ROOM	FE	Spine2	L5S1	L	1.0572	0.1760	1.1032	0.0361	1.1488	1.4509	1.1678	1.4286	0.7614
ROOM	FE	Spine2	L5S1	nl	0.8253	0.6451	2.2783	0.7963	1.1026	0.8692	1.9321	3.6292	0.8259
ROOM	FE	Spine3	L5S1	nl	2.5743	-.4483	0.2588	-.6798	0.4165	0.5675	0.9438	-6.212	1.5687
ROOM	FE	Spine4	L1L2	L	1.0198	0.9599	0.7793	1.0854	0.2057	1.3452	4.4711	0.8456	0.8477
ROOM	FE	Spine4	L1L2	nl	1.0777	2.8117	0.8805	0.8403	1.0268	0.9090	0.9713	0.8120	0.7389
ROOM	FE	Spine4	L3L4	nl	1.2997	1.2163	0.9223	0.6498	0.9708	0.8865	1.0730	1.6908	0.9964
ROOM	FE	Spine4	L5S1	L	2.3054	0.0954	1.3328	0.1520	5.6075	0.6685	1.7231	0.4805	0.9697
ROOM	FE	Spine4	L5S1	nl	1.1992	0.8643	0.8047	-.8516	1.2090	1.4592	0.7117	0.4906	0.9080
ROOM	FE	Spine5	L3L4	L	1.1029	1.0356	1.0126	0.9781	0.4604	1.4340	2.5567	0.6095	1.0130
ROOM	FE	Spine6	L3L4	L	1.6972	-.2819	5.1923	-.7122	5.3106	3.0601	2.0706	2.9320	2.5500
ROOM	FE	Spine7	L1L2	L	1.0356	-.4087	1.8248	0.0840	0.3003	0.4906	4.1645	0.5750	0.7823
ROOM	FE	Spine7	L1L2	nl	1.0982	0.2199	0.3519	-.2581	1.1597	0.7840	0.2911	3.1971	0.6476
ROOM	FE	Spine7	L5S1	L	0.7105	3.3246	0.7099	3.3239	0.8171	1.9302	0.8171	1.9302	0.6066
ROOM	FE	Spine7	L5S1	nl	1.0531	1.0288	1.0531	1.0288	1.0216	0.9784	1.0216	0.9784	0.9880
ROOM	FE	Spine8	L1L2	nl	1.0052	0.7239	1.0059	0.7236	1.0072	1.3788	1.0072	1.3788	0.8879
ROOM	FE	Spine8	L3L4	L	0.9926	1.6303	0.8604	0.8338	0.6496	1.0064	1.4056	1.0898	0.9268
ROOM	FE	Spine8	L3L4	nl	1.0601	-1.212	1.1795	0.8836	1.1022	0.9794	1.1473	0.9157	0.9333
ROOM	FE	Spine8	L5S1	nl	0.9833	0.8269	0.6948	2.3879	1.0633	5.3286	0.5772	1.4756	1.8146
ROOM	LB	Spine1	L3L4	L	1.1277	2.6122	1.1279	2.6125	1.1507	-1.566	1.1507	-1.566	0.9624
ROOM	LB	Spine1	L5S1	L	0.4730	0.0220	1.1645	-.0477	3.4947	3.6520	0.2709	0.4703	0.6372
ROOM	LB	Spine2	L1L2	L	1.7151	0.6681	0.6779	1.0879	1.2180	-16.06	0.8873	0.3100	0.7451
ROOM	LB	Spine2	L3L4	L	1.1490	0.8651	1.1490	0.8651	1.2033	0.2154	1.2033	0.2155	2.1324
ROOM	LB	Spine2	L3L4	nl	3.0558	0.0201	3.1172	0.0081	1.3577	-.4684	3.8762	0.2440	1.5149
ROOM	LB	Spine2	L5S1	L	0.9559	0.5502	0.9559	0.5502	0.9878	-.5965	0.9879	-.5965	0.4467

Temp	DIR	Spine	Segment	Load	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	LB	Spine2	L5S1	nl	1.1084	1.0488	1.0994	1.0279	1.1577	0.3492	1.1632	0.3457	0.4354
ROOM	LB	Spine3	L1L2	L	1.0939	1.1739	0.8419	1.5965	0.9830	1.3465	1.0460	1.3500	0.6659
ROOM	LB	Spine3	L5S1	L	1.0882	1.0127	1.0912	1.0150	0.9530	3.7069	0.9531	3.7062	1.3222
ROOM	LB	Spine4	L3L4	L	0.7296	0.8395	2.1032	5.4620	2.1845	0.7030	0.7446	2.4561	1.0665
ROOM	LB	Spine4	L3L4	nl	-.3972	-.6311	0.6035	0.7096	-.3638	0.6051	0.6895	0.7929	0.9641
ROOM	LB	Spine6	L3L4	L	1.0111	2.7690	1.0059	2.7870	0.9606	0.4732	0.8630	0.5007	0.8881
ROOM	LB	Spine7	L1L2	L	0.8934	0.3994	0.8933	0.3990	0.9392	1.3798	0.9380	1.3750	1.2572
ROOM	LB	Spine7	L1L2	nl	4.3358	-.1904	1.4410	0.5976	3.9218	1.2542	1.4603	2.3471	0.8814
ROOM	LB	Spine7	L5S1	L	1.1349	0.7783	1.1349	0.7783	1.2955	1.2331	1.2955	1.2331	1.1096
ROOM	LB	Spine8	L1L2	L	0.8304	0.4821	0.8304	0.4821	0.7804	1.4563	0.7805	1.4563	0.8901
ROOM	LB	Spine8	L1L2	nl	2.8421	3.2354	2.8465	3.2300	2.9615	0.4571	2.9659	0.4570	1.0597
ROOM	LB	Spine8	L3L4	L	0.9896	1.1731	0.9890	1.1729	0.9974	0.8613	0.9979	0.8612	1.0540
ROOM	LB	Spine8	L5S1	nl	4.5497	0.7170	1.3453	0.3367	5.7387	0.7025	0.6927	-.3361	1.1301

C.1.6. Temperature-Targeted Effect Flexibility Parameters

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	AR	Spine1	L1L2	L	0.6570	0.7238	0.7452	1.1342	1.1016	1.0803	1.4269	1.4730	1.4498
ROOM	AR	Spine1	L1L2	nl	0.7970	0.7118	0.6682	0.8384	0.8931	0.9200	1.3882	1.3607	1.3737
ROOM	AR	Spine1	L3L4	L	0.7119	0.2865	0.3058	0.4295	0.4024	0.3901	1.2504	1.2955	1.2726
ROOM	AR	Spine1	L5S1	L	0.6740	0.6338	0.6760	1.0030	0.9403	0.8685	1.3583	1.2823	1.3214
ROOM	AR	Spine2	L1L2	L	0.8288	0.6300	0.6385	0.7704	0.7601	0.7545	1.1908	1.1731	1.1819
ROOM	AR	Spine2	L1L2	nl	0.7442	0.5097	0.5328	0.7159	0.6848	0.6764	1.2576	1.2843	1.2708
ROOM	AR	Spine2	L5S1	L	0.9216	0.5390	0.5326	0.5780	0.5849	0.5869	1.1460	1.0265	1.0818
ROOM	AR	Spine2	L5S1	nl	0.7507	0.4025	0.4737	0.6310	0.5362	0.6980	1.5192	0.9725	1.1949
ROOM	AR	Spine3	L1L2	L	0.6024	0.5341	0.5741	0.9529	0.8866	0.9037	1.5584	1.5687	1.5635
ROOM	AR	Spine3	L1L2	nl	0.6913	0.6750	0.7171	1.0373	0.9764	1.1250	1.4768	1.6232	1.5455
ROOM	AR	Spine3	L5S1	L	0.4335	0.3043	0.3618	0.8345	0.7018	0.8176	2.1833	2.2950	2.2374
ROOM	AR	Spine4	L1L2	L	0.7124	0.5556	0.5490	0.7706	0.7799	0.7845	1.4488	1.3946	1.4211
ROOM	AR	Spine4	L1L2	nl	0.6925	0.4361	0.5729	0.8272	0.6297	0.9271	1.6067	1.6020	1.6044
ROOM	AR	Spine4	L5S1	L	0.6477	0.5426	0.5812	0.8974	0.8378	0.8168	1.6522	1.3576	1.5004
ROOM	AR	Spine4	L5S1	nl	0.6578	0.8751	0.8061	1.2255	1.3304	1.3652	1.7536	1.6507	1.7019
ROOM	AR	Spine5	L3L4	L	0.9898	0.9716	0.8947	0.9039	0.9816	1.0094	1.0414	1.0703	1.0553
ROOM	AR	Spine6	L3L4	L	0.7931	0.6266	0.6717	0.8470	0.7901	0.7627	1.2220	1.1171	1.1694
ROOM	AR	Spine7	L1L2	L	0.8792	0.9741	0.9418	1.0712	1.1079	0.9820	1.1581	0.9775	1.0640
ROOM	AR	Spine7	L1L2	nl	0.9211	1.0105	0.9518	1.0333	1.0970	1.0624	1.0230	1.2130	1.1054
ROOM	AR	Spine7	L3L4	L	0.7682	0.2777	0.2747	0.3575	0.3615	0.4037	1.3691	1.6610	1.5061
ROOM	AR	Spine7	L5S1	L	0.8317	0.4406	1.1085	1.3328	0.5297	0.6643	1.2905	1.4988	1.4021
ROOM	AR	Spine7	L5S1	nl	0.9936	0.6655	0.6848	0.6893	0.6698	0.6686	0.9280	1.0386	0.9817
ROOM	AR	Spine8	L1L2	L	0.9036	0.8805	0.9167	1.0145	0.9745	0.9685	1.0561	1.0596	1.0579
ROOM	AR	Spine8	L1L2	nl	0.8796	0.9405	0.9638	1.0958	1.0692	1.0672	1.0925	1.0879	1.0900
ROOM	AR	Spine8	L3L4	L	1.0213	0.7875	0.8470	0.8293	0.7710	0.7512	0.8592	0.9120	0.8850
ROOM	AR	Spine8	L3L4	nl	1.1183	0.8573	1.0048	0.8985	0.7666	0.7389	0.7291	0.7391	0.7340
ROOM	AR	Spine8	L5S1	L	0.4906	0.3198	0.2435	0.4964	0.6518	0.6649	2.0864	3.4315	2.5911
ROOM	AR	Spine8	L5S1	nl	0.7630	0.6467	0.6917	0.9066	0.8476	0.8408	1.2748	1.2254	1.2521
ROOM	FE	Spine1	L1L2	L	2.0929	2.8095	2.2393	1.0699	1.3424	1.4352	0.5488	0.6843	0.6173
ROOM	FE	Spine1	L3L4	L	0.8926	0.4844	0.4787	0.5363	0.5427	0.5416	1.1573	1.1979	1.1763

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine1	L5S1	L	0.7706	0.7961	0.9920	1.2873	1.0330	1.0457	1.3320	1.6082	1.4341
ROOM	FE	Spine2	L1L2	nl	1.5025	0.9473	1.1751	0.7821	0.6305	0.5934	0.4036	0.5890	0.4763
ROOM	FE	Spine2	L3L4	L	1.6883	0.8443	0.9634	0.5706	0.5001	0.4927	0.5514	0.5096	0.5321
ROOM	FE	Spine2	L3L4	nl	1.9255	1.9750	2.0336	1.0561	1.0257	0.5393	0.2253	0.2945	0.2569
ROOM	FE	Spine2	L5S1	L	0.7614	0.7800	0.7990	1.0493	1.0244	0.9084	1.1420	1.1367	1.1393
ROOM	FE	Spine2	L5S1	nl	0.8259	0.8447	0.9791	1.1854	1.0227	0.8532	0.6792	0.7047	0.6899
ROOM	FE	Spine3	L5S1	nl	1.5687	1.2736	1.5063	0.9602	0.8119	0.9937	0.5569	0.4069	0.4701
ROOM	FE	Spine4	L1L2	L	0.8477	0.9149	0.9361	1.1043	1.0793	1.2418	1.4702	1.1832	1.3141
ROOM	FE	Spine4	L1L2	nl	0.7389	0.5254	0.5385	0.7288	0.7110	0.7483	1.4203	1.3750	1.3976
ROOM	FE	Spine4	L3L4	nl	0.9964	1.1204	1.1518	1.1559	1.1245	1.1097	0.8704	0.8508	0.8604
ROOM	FE	Spine4	L5S1	L	0.9697	1.0073	2.0242	2.0873	1.0387	1.2160	0.8164	0.4273	0.6035
ROOM	FE	Spine4	L5S1	nl	0.9080	1.3646	1.0778	1.1869	1.5029	1.4334	1.1067	0.9074	0.9994
ROOM	FE	Spine5	L3L4	L	1.0130	0.9446	0.8605	0.8495	0.9324	0.8153	0.9452	0.9564	0.9511
ROOM	FE	Spine6	L3L4	L	2.5500	1.7064	3.8884	1.5249	0.6692	0.4564	0.1238	0.1105	0.1173
ROOM	FE	Spine7	L1L2	L	0.7823	0.5749	0.9629	1.2308	0.7348	0.7788	0.5653	0.9936	0.7367
ROOM	FE	Spine7	L1L2	nl	0.6476	0.7312	0.7366	1.1374	1.1292	2.3400	2.8584	3.0718	2.9585
ROOM	FE	Spine7	L5S1	L	0.6066	0.6453	0.5375	0.8861	1.0638	1.0552	2.3151	2.0123	2.1726
ROOM	FE	Spine7	L5S1	nl	0.9880	0.8756	0.9377	0.9491	0.8862	0.8880	0.9606	0.9902	0.9761
ROOM	FE	Spine8	L1L2	nl	0.8879	0.9456	0.9458	1.0652	1.0650	1.0628	1.1210	1.1192	1.1202
ROOM	FE	Spine8	L3L4	L	0.9268	0.9946	0.9427	1.0171	1.0732	1.1424	1.1685	1.2399	1.2038
ROOM	FE	Spine8	L3L4	nl	0.9333	0.9100	1.0197	1.0926	0.9750	0.9524	0.9221	0.9547	0.9386
ROOM	FE	Spine8	L5S1	nl	1.8146	1.7058	1.5474	0.8527	0.9400	0.8849	0.6491	0.8334	0.7122
ROOM	LB	Spine1	L3L4	L	0.9624	0.6655	0.7591	0.7888	0.6915	0.6848	0.9139	0.8957	0.9043
ROOM	LB	Spine1	L5S1	L	0.6372	0.6550	0.7213	1.1321	1.0280	1.0087	1.1042	0.9691	1.0494
ROOM	LB	Spine2	L1L2	L	0.7451	0.7126	0.7959	1.0683	0.9564	0.9736	1.2374	1.1840	1.2110
ROOM	LB	Spine2	L3L4	L	2.1324	2.2584	2.4878	1.1667	1.0591	1.0041	0.4090	0.3906	0.3995
ROOM	LB	Spine2	L3L4	nl	1.5149	0.4159	1.4648	0.9669	0.2745	0.3919	0.2137	0.2435	0.2282
ROOM	LB	Spine2	L5S1	L	0.4467	0.1406	0.1406	0.3148	0.3147	0.3149	2.3053	2.2307	2.2667
ROOM	LB	Spine2	L5S1	nl	0.4354	0.3094	0.3386	0.7776	0.7107	0.6889	2.0712	1.9702	2.0177
ROOM	LB	Spine3	L1L2	L	0.6659	0.7162	0.6437	0.9666	1.0755	1.2564	2.2089	2.2680	2.2369

Temp	DIR	Spine	Segment	Load	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	LB	Spine3	L5S1	L	1.3222	1.8463	1.7601	1.3312	1.3964	1.3562	0.7006	0.8010	0.7473
ROOM	LB	Spine4	L3L4	L	1.0665	0.8184	1.1548	1.0827	0.7673	0.6866	0.6218	0.5728	0.5963
ROOM	LB	Spine4	L3L4	nl	0.9641	0.1580	0.1826	0.1894	0.1639	0.5502	2.9632	2.9789	2.9712
ROOM	LB	Spine6	L3L4	L	0.8881	0.6799	0.6658	0.7497	0.7656	0.7767	1.1074	1.2276	1.1654
ROOM	LB	Spine7	L1L2	L	1.2572	1.1975	1.1464	0.9118	0.9525	0.9891	0.8882	0.8454	0.8668
ROOM	LB	Spine7	L1L2	nl	0.8814	1.1004	3.2677	3.7073	1.2485	2.1959	0.5160	0.5852	0.5520
ROOM	LB	Spine7	L5S1	L	1.1096	1.0358	1.1476	1.0343	0.9335	0.8958	0.7946	0.6961	0.7414
ROOM	LB	Spine8	L1L2	L	0.8901	0.8148	0.6880	0.7729	0.9154	0.9522	1.3399	1.4258	1.3813
ROOM	LB	Spine8	L1L2	nl	1.0597	0.8489	2.3654	2.2322	0.8011	0.7866	0.3381	0.3244	0.3313
ROOM	LB	Spine8	L3L4	L	1.0540	0.9872	0.9855	0.9350	0.9366	0.9377	0.9577	0.9496	0.9538
ROOM	LB	Spine8	L5S1	nl	1.1301	0.8150	1.3958	1.2351	0.7212	0.7000	0.3646	0.4160	0.3855

C.2. Stepwise Loading Tests

C.2.1. DIP-Boltzmann Parameters

TEMP	DIR	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	AR	Spine1	L3L4	0	0.2820	-1.949	0.2820	-1.949	0.2421	-.2073	0.2421	-.2073	3.9984
BODY	AR	Spine1	L3L4	1	0.3567	-.5361	0.3567	-.5361	0.3682	1.0965	0.3682	1.0965	2.6759
ROOM	AR	Spine1	L3L4	0	0.3668	-.9066	0.3668	-.9066	0.3790	0.4692	0.3790	0.4692	2.3932
ROOM	AR	Spine1	L3L4	1	0.3989	-.1818	0.3989	-.1818	0.3976	0.4790	0.3976	0.4790	1.9050
BODY	AR	Spine1	L5S1	0	0.3124	-1.477	0.3123	-1.476	0.3472	1.7697	0.3472	1.7697	1.9485
BODY	AR	Spine1	L5S1	1	0.2363	-2.346	0.2363	-2.346	0.1661	-5.347	0.6032	3.2951	1.7289
ROOM	AR	Spine1	L5S1	0	0.3036	-1.782	0.3036	-1.782	0.2885	0.9430	0.2885	0.9430	1.2157
ROOM	AR	Spine1	L5S1	1	0.3395	-.8879	0.3395	-.8880	0.2878	1.4270	0.2878	1.4270	0.9659
BODY	AR	Spine5	L1L2	0	0.3098	-1.300	0.3098	-1.300	0.2996	1.1308	0.2996	1.1308	5.1049
BODY	AR	Spine5	L1L2	1	0.3284	-.5910	0.3284	-.5910	0.3216	0.6583	0.3216	0.6583	2.7087
ROOM	AR	Spine5	L1L2	0	0.2958	-.8512	0.2958	-.8512	0.3028	0.9453	0.3028	0.9453	2.6075
ROOM	AR	Spine5	L1L2	1	0.3240	-.1397	0.3240	-.1397	0.3229	0.6796	0.3229	0.6796	2.0320
BODY	AR	Spine5	L3L4	0	0.2800	-1.857	0.3154	-.0039	0.5587	4.4767	0.5181	-2.822	5.8115
BODY	AR	Spine5	L3L4	1	0.5535	-4.068	0.6640	3.6665	0.5051	-3.166	0.6461	4.1379	4.7475
ROOM	AR	Spine5	L3L4	0	0.2689	-.2128	0.2690	-.2132	0.4183	-4.083	0.5768	4.4952	4.9922
ROOM	AR	Spine5	L3L4	1	0.2914	-.1713	0.2914	-.1713	0.5110	-3.557	0.6397	4.1266	4.6991
BODY	AR	Spine6	L3L4	0	0.4994	1.9581	0.7188	-3.948	0.6121	3.9515	0.6807	-2.424	9.1771
BODY	AR	Spine6	L3L4	1	0.5497	2.3055	0.8111	-3.637	0.7431	-2.367	0.6587	3.8370	8.1851
ROOM	AR	Spine6	L3L4	0	0.3595	-.3948	0.3607	-.3784	0.4882	-1.460	0.5665	3.9679	7.7799
ROOM	AR	Spine6	L3L4	1	0.3855	0.0780	0.3853	0.0778	0.7452	3.3857	0.4123	-1.336	6.4915
BODY	AR	Spine7	L3L4	0	0.3168	-1.758	0.3167	-1.757	0.5501	-.1413	0.3615	4.1440	3.3383
BODY	AR	Spine7	L3L4	1	0.3352	-.6585	0.3352	-.6585	0.7369	4.4370	0.4664	-1.199	2.4225
ROOM	AR	Spine7	L3L4	0	0.3180	-.3246	0.3180	-.3246	0.3575	1.7222	0.3566	1.6591	2.2828
ROOM	AR	Spine7	L3L4	1	0.3519	0.5149	0.3519	0.5149	0.3601	1.5959	0.3593	1.5874	1.8611
BODY	FE	Spine1	L3L4	0	0.2470	0.9205	0.2470	0.9205	0.6677	6.8646	0.5500	-.7010	5.5832
BODY	FE	Spine1	L3L4	1	0.5552	3.6889	0.5545	-3.727	0.8042	5.7385	0.4591	-1.506	3.1724
ROOM	FE	Spine1	L3L4	0	0.3543	-2.180	0.3543	-2.180	0.5678	-3.420	0.7100	3.5515	2.4168
ROOM	FE	Spine1	L3L4	1	0.2957	0.5235	0.2957	0.5236	0.8423	5.4747	0.4993	-2.185	2.4431
BODY	FE	Spine1	L5S1	0	0.6716	2.6209	0.4543	-2.921	1.1003	4.8879	0.3777	2.4597	9.3670
BODY	FE	Spine1	L5S1	1	0.8225	3.1165	0.5218	-1.819	1.1311	4.6598	0.4988	2.2681	8.6810

TEMP	DIR	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine1	L5S1	0	0.4313	-1.786	1.1714	3.2622	0.3933	3.2290	1.4689	5.5409	7.0713
ROOM	FE	Spine1	L5S1	1	1.2447	3.4756	0.4815	-1.100	1.8234	5.6252	0.4797	2.6133	6.6746
BODY	FE	Spine5	L1L2	0	0.4327	-1.460	3.3530	-.6210	0.4235	1.6959	2.1188	0.5287	15.868
BODY	FE	Spine5	L1L2	1	0.4743	-.3510	6.2469	-.4716	0.5451	2.0709	3.2474	0.1641	14.089
ROOM	FE	Spine5	L1L2	0	0.4844	-.0160	4.0927	-.3163	0.5933	1.7085	7.6540	0.3621	13.665
ROOM	FE	Spine5	L1L2	1	0.6813	1.0837	5.3273	-.1312	0.8516	1.7704	7.1645	0.2272	12.504
BODY	FE	Spine5	L3L4	0	0.4315	0.1676	2.0195	1.1570	0.5083	2.6176	1.2641	1.8884	19.371
BODY	FE	Spine5	L3L4	1	0.4811	0.9789	1.6633	1.0197	0.5842	2.3806	1.3760	1.8457	18.932
ROOM	FE	Spine5	L3L4	0	0.5137	0.8913	1.9410	1.2151	0.6684	2.6618	1.7721	1.2493	20.292
ROOM	FE	Spine5	L3L4	1	1.7007	0.9969	0.5256	1.0157	0.6350	2.6250	1.4876	1.4568	19.178
BODY	FE	Spine6	L3L4	0	0.4989	-6.193	0.4232	2.4525	0.4778	5.3674	0.4804	-2.818	5.1190
BODY	FE	Spine6	L3L4	1	0.4888	2.4908	0.8701	-6.024	0.5275	-3.714	0.7160	4.9628	3.9538
ROOM	FE	Spine6	L3L4	0	1.6453	0.8186	0.4173	-.9529	2.4731	2.8528	0.4094	2.7302	11.131
ROOM	FE	Spine6	L3L4	1	1.4584	1.6107	0.4200	0.7442	1.8159	2.8843	0.4870	2.8809	10.082
BODY	FE	Spine7	L3L4	0	0.5419	2.7820	0.5589	-4.585	0.7563	5.8786	0.4369	-1.250	4.2190
BODY	FE	Spine7	L3L4	1	0.6425	-4.610	0.5863	2.5623	0.9502	5.0697	0.4910	-2.094	2.7143
ROOM	FE	Spine7	L3L4	0	0.5428	-4.308	0.6830	2.6597	1.1632	5.1965	0.4791	-1.258	2.4251
ROOM	FE	Spine7	L3L4	1	0.7046	2.3804	0.6407	-4.122	0.4781	-2.097	0.9848	4.2888	1.6751
BODY	LB	Spine1	L3L4	1	0.7844	-2.627	0.4302	0.6349	0.5474	3.5391	0.7392	-.9129	10.641
ROOM	LB	Spine1	L3L4	0	1.3852	2.7860	0.3659	-1.114	1.5316	4.8080	0.3907	1.6185	11.157
ROOM	LB	Spine1	L3L4	1	1.4626	3.0587	0.3820	-.7824	0.4043	1.0626	1.7873	4.5839	10.241
BODY	LB	Spine1	L5S1	0	0.4770	-4.138	0.9257	2.2884	1.3579	5.0281	0.5377	0.0247	6.9570
BODY	LB	Spine1	L5S1	1	0.4315	-2.623	1.0637	2.7644	1.6569	4.7467	0.3954	1.0060	6.2980
ROOM	LB	Spine1	L5S1	0	0.5574	-3.268	0.9294	1.2639	1.5081	3.4725	0.4370	2.7900	4.2634
ROOM	LB	Spine1	L5S1	1	0.7896	1.7655	0.5420	-2.145	1.3875	3.4894	0.4486	2.2506	4.0771
BODY	LB	Spine5	L1L2	0	8.9061	-1.299	0.5249	-1.457	0.4753	1.8727	5.6125	0.3269	24.764
BODY	LB	Spine5	L1L2	1	7.6709	-.8246	0.4955	-1.132	7.6645	0.2266	0.4704	1.3772	22.168
ROOM	LB	Spine5	L1L2	0	2.2391	0.3604	0.4467	-.8812	2.2435	1.3410	0.4518	1.7634	18.696
ROOM	LB	Spine5	L1L2	1	0.4631	-.2450	2.2854	0.4684	2.9485	1.3256	0.4487	1.3422	16.771
BODY	LB	Spine5	L3L4	0	1.9817	-.5626	0.3931	-2.111	0.3652	1.5928	1.5966	1.1193	20.129
BODY	LB	Spine5	L3L4	1	2.0322	-.4111	0.4104	-1.270	0.4085	1.7425	1.5770	1.2803	18.964
ROOM	LB	Spine5	L3L4	0	7.1285	-3.581	0.4661	-2.916	0.3924	-.1888	5.3846	-1.570	18.975
ROOM	LB	Spine5	L3L4	1	0.4947	-2.649	3.8809	-3.494	0.4185	-.6404	3.8007	-1.563	18.097

TEMP	DIR	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	LB	Spine6	L3L4	0	0.7945	2.0402	0.6138	-4.933	0.9679	4.9650	0.4969	-1.781	18.294
BODY	LB	Spine6	L3L4	1	0.8985	2.7384	0.6195	-4.008	0.4742	-1.258	1.1386	5.0975	15.890
ROOM	LB	Spine6	L3L4	0	0.5543	1.4091	0.6001	-4.975	0.5444	-2.271	0.5228	4.1945	15.874
ROOM	LB	Spine6	L3L4	1	0.5729	2.1976	0.6186	-4.066	0.6978	4.4216	0.5521	-2.211	14.112
BODY	LB	Spine7	L3L4	0	0.7356	-.0121	0.6535	-3.323	1.1329	-1.231	0.8223	4.1520	20.286
BODY	LB	Spine7	L3L4	1	0.3428	-.1552	0.8202	0.2689	0.3898	2.0785	0.8721	-.0341	26.477
ROOM	LB	Spine7	L3L4	0	0.8417	0.5404	0.7833	-3.183	1.2056	-1.331	0.7350	3.8281	17.064
ROOM	LB	Spine7	L3L4	1	0.8768	1.2233	0.9249	-3.130	0.9419	-1.759	0.7793	3.6543	15.795

C.2.2 Flexibiity Parameters

TEMP	DIR	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	AR	Spine1	L3L4	0	3.9984	5.4606	0.4965	0.1242	1.3657	1.7420	3.5604	4.1469	3.8537
BODY	AR	Spine1	L3L4	1	2.6759	3.8260	0.3940	0.1472	1.4298	1.6320	4.2126	4.0818	4.1472
ROOM	AR	Spine1	L3L4	0	2.3932	2.9038	0.3064	0.1280	1.2134	1.3760	4.5755	4.4273	4.5014
ROOM	AR	Spine1	L3L4	1	1.9050	1.1372	0.1252	0.0657	0.5970	0.6620	5.2694	5.2869	5.2782
BODY	AR	Spine1	L5S1	0	1.9485	5.3084	0.5128	0.2632	2.7243	3.2460	6.6866	6.0156	6.3511
BODY	AR	Spine1	L5S1	1	1.7289	3.1374	0.3830	0.2215	1.8147	3.5620	9.9088	8.8802	9.3945
ROOM	AR	Spine1	L5S1	0	1.2157	2.6569	0.2427	0.1997	2.1856	2.7240	10.944	11.517	11.231
ROOM	AR	Spine1	L5S1	1	0.9659	1.8189	0.1806	0.1870	1.8830	2.3160	12.304	14.510	13.407
BODY	AR	Spine5	L1L2	0	5.1049	10.081	0.9362	0.1834	1.9748	2.4300	2.5499	2.6370	2.5934
BODY	AR	Spine5	L1L2	1	2.7087	2.8362	0.2747	0.1014	1.0471	1.2500	4.5080	4.6039	4.5559
ROOM	AR	Spine5	L1L2	0	2.6075	3.7797	0.3490	0.1339	1.4496	1.7960	5.2091	5.0883	5.1487
ROOM	AR	Spine5	L1L2	1	2.0320	1.3923	0.1344	0.0662	0.6852	0.8200	6.0828	6.1025	6.0926
BODY	AR	Spine5	L3L4	0	5.8115	8.5743	0.7993	0.1375	1.4754	1.8300	2.3668	2.9131	2.6400
BODY	AR	Spine5	L3L4	1	4.7475	3.0205	0.2963	0.0624	0.6362	0.7840	4.2670	3.6690	3.9680
ROOM	AR	Spine5	L3L4	0	4.9922	2.3776	0.4262	0.0854	0.4763	1.0700	2.9846	4.0652	3.5249
ROOM	AR	Spine5	L3L4	1	4.6991	2.1414	0.3695	0.0786	0.4557	0.8640	2.9259	4.0345	3.4802
BODY	AR	Spine6	L3L4	0	9.1771	15.542	1.5164	0.1652	1.6936	2.0880	1.4112	1.6312	1.5212
BODY	AR	Spine6	L3L4	1	8.1851	11.221	1.1939	0.1459	1.3709	1.7480	1.6424	1.8386	1.7405
ROOM	AR	Spine6	L3L4	0	7.7799	11.830	1.2457	0.1601	1.5206	1.8240	1.4368	1.5573	1.4970
ROOM	AR	Spine6	L3L4	1	6.4915	6.3956	1.0029	0.1545	0.9852	1.5860	1.6082	1.5609	1.5846
BODY	AR	Spine7	L3L4	0	3.3383	10.385	1.0088	0.3022	3.1110	3.3960	3.8711	3.3369	3.6040
BODY	AR	Spine7	L3L4	1	2.4225	5.2033	0.5633	0.2325	2.1479	2.7960	4.9920	5.0234	5.0077
ROOM	AR	Spine7	L3L4	0	2.2828	3.9543	0.3939	0.1725	1.7322	2.0140	5.5507	4.9437	5.2472
ROOM	AR	Spine7	L3L4	1	1.8611	1.7415	0.1783	0.0958	0.9357	1.0780	6.1209	5.9883	6.0546
BODY	FE	Spine1	L3L4	0	5.5832	11.427	0.9187	0.1645	2.0467	2.4540	2.9196	3.3659	3.1427
BODY	FE	Spine1	L3L4	1	3.1724	6.4976	0.6456	0.2035	2.0481	2.8940	5.4332	5.3326	5.3829
ROOM	FE	Spine1	L3L4	0	2.4168	4.7769	0.5383	0.2228	1.9766	2.5220	4.7294	6.8533	5.7913
ROOM	FE	Spine1	L3L4	1	2.4431	2.8968	0.3807	0.1558	1.1857	1.9060	5.5706	8.0617	6.8161
BODY	FE	Spine1	L5S1	0	9.3670	33.276	3.9251	0.4190	3.5525	3.9740	1.3095	0.7422	1.0258
BODY	FE	Spine1	L5S1	1	8.6810	23.521	2.9459	0.3393	2.7095	2.8300	1.2425	0.7160	0.9793
ROOM	FE	Spine1	L5S1	0	7.0713	23.750	3.4047	0.4815	3.3586	3.6500	1.7321	0.9086	1.3204
ROOM	FE	Spine1	L5S1	1	6.6746	18.741	2.9861	0.4474	2.8078	2.9940	1.6154	1.0910	1.3532
BODY	FE	Spine5	L1L2	0	15.868	32.076	7.6917	0.4847	2.0214	1.6440	0.1865	0.2653	0.2259

TEMP	DIR	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	FE	Spine5	L1L2	1	14.089	20.818	6.4185	0.4556	1.4777	1.1420	0.1076	0.3320	0.2198
ROOM	FE	Spine5	L1L2	0	13.665	16.097	6.6234	0.4847	1.1779	0.9460	0.1651	0.3361	0.2506
ROOM	FE	Spine5	L1L2	1	12.504	6.5700	4.0599	0.3247	0.5254	0.4420	0.1512	0.2110	0.1811
BODY	FE	Spine5	L3L4	0	19.371	29.511	5.6669	0.2925	1.5235	1.1600	0.1850	0.2458	0.2154
BODY	FE	Spine5	L3L4	1	18.932	20.845	4.6841	0.2474	1.1011	1.0040	0.2030	0.2234	0.2132
ROOM	FE	Spine5	L3L4	0	20.292	18.130	2.9261	0.1442	0.8934	0.5000	0.1630	0.1836	0.1733
ROOM	FE	Spine5	L3L4	1	19.178	19.585	4.0434	0.2108	1.0212	0.8200	0.1912	0.2145	0.2028
BODY	FE	Spine6	L3L4	0	5.1190	13.397	1.1195	0.2187	2.6171	3.4100	3.8500	3.6388	3.7444
BODY	FE	Spine6	L3L4	1	3.9538	9.2531	0.8494	0.2148	2.3403	3.5340	5.9926	5.8977	5.9452
ROOM	FE	Spine6	L3L4	0	11.131	29.765	6.2347	0.5601	2.6742	2.6400	0.5479	0.3377	0.4428
ROOM	FE	Spine6	L3L4	1	10.082	16.532	3.5794	0.3550	1.6397	1.5020	0.4634	0.3688	0.4161
BODY	FE	Spine7	L3L4	0	4.2190	12.655	1.1704	0.2774	2.9996	3.8860	3.9430	3.8182	3.8806
BODY	FE	Spine7	L3L4	1	2.7143	6.6578	0.6926	0.2552	2.4528	3.3200	6.1872	6.5677	6.3774
ROOM	FE	Spine7	L3L4	0	2.4251	6.4927	0.7229	0.2981	2.6773	3.3100	6.5357	6.6196	6.5777
ROOM	FE	Spine7	L3L4	1	1.6751	3.2588	0.3872	0.2311	1.9454	2.6660	9.1523	8.7832	8.9677
BODY	LB	Spine1	L3L4	1	10.641	23.701	2.9386	0.2761	2.2273	2.4560	0.7802	0.9291	0.8547
ROOM	LB	Spine1	L3L4	0	11.157	24.736	4.3835	0.3929	2.2171	2.2840	0.7676	0.6250	0.6963
ROOM	LB	Spine1	L3L4	1	10.241	16.296	3.3354	0.3257	1.5912	1.6820	0.7379	0.6540	0.6960
BODY	LB	Spine1	L5S1	0	6.9570	22.641	2.6136	0.3757	3.2544	3.4960	2.1270	1.7167	1.9219
BODY	LB	Spine1	L5S1	1	6.2980	16.604	2.4536	0.3896	2.6363	2.9740	1.9516	1.3095	1.6306
ROOM	LB	Spine1	L5S1	0	4.2634	16.756	2.3489	0.5510	3.9303	4.1040	2.3917	1.1967	1.7942
ROOM	LB	Spine1	L5S1	1	4.0771	11.960	1.7661	0.4332	2.9334	3.0900	2.2305	1.2559	1.7432
BODY	LB	Spine5	L1L2	0	24.764	59.172	16.941	0.6841	2.3895	2.7040	0.2139	0.4277	0.3208
BODY	LB	Spine5	L1L2	1	22.168	37.916	13.905	0.6272	1.7104	1.7700	0.1472	0.4200	0.2836
ROOM	LB	Spine5	L1L2	0	18.696	32.136	7.3492	0.3931	1.7188	1.3540	0.1958	0.1782	0.1870
ROOM	LB	Spine5	L1L2	1	16.771	19.580	5.7595	0.3434	1.1675	1.0080	0.1927	0.1533	0.1730
BODY	LB	Spine5	L3L4	0	20.129	49.843	9.7708	0.4854	2.4762	2.2400	0.2392	0.2405	0.2399
BODY	LB	Spine5	L3L4	1	18.964	41.911	8.8932	0.4690	2.2101	2.0420	0.2136	0.2456	0.2296
ROOM	LB	Spine5	L3L4	0	18.975	43.020	11.894	0.6268	2.2672	2.3860	0.3033	0.5340	0.4186
ROOM	LB	Spine5	L3L4	1	18.097	34.666	10.456	0.5778	1.9155	1.9460	0.2009	0.2250	0.2129
BODY	LB	Spine6	L3L4	0	18.294	53.011	5.7890	0.3164	2.8977	3.3900	0.9090	0.8854	0.8972
BODY	LB	Spine6	L3L4	1	15.890	39.475	4.8697	0.3065	2.4843	2.9900	1.0402	0.9756	1.0079
ROOM	LB	Spine6	L3L4	0	15.874	39.628	3.3449	0.2107	2.4965	2.7940	0.9020	0.9049	0.9034

TEMP	DIR	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	LB	Spine6	L3L4	1	14.112	27.528	2.7380	0.1940	1.9507	2.4480	1.0014	1.0894	1.0454
BODY	LB	Spine7	L3L4	0	20.286	61.728	6.7363	0.3321	3.0428	2.8760	0.3928	0.6502	0.5215
BODY	LB	Spine7	L3L4	1	26.477	22.211	2.1238	0.0802	0.8389	0.4800	0.2611	0.2601	0.2606
ROOM	LB	Spine7	L3L4	0	17.064	42.759	4.8553	0.2845	2.5058	2.1740	0.4828	0.7383	0.6106
ROOM	LB	Spine7	L3L4	1	15.795	29.453	3.7705	0.2387	1.8646	1.7760	0.6237	0.8286	0.7261

C.2.3 Loading-Type-Targeted Effect DIP-Boltzmann Parameters

TEMP	DIR	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	AR	Spine1	L3L4	0	0.7906	3.6360	0.7906	3.6361	0.6577	-.1891	0.6577	-.1891	1.4942
ROOM	AR	Spine1	L3L4	0	0.9194	4.9858	0.9194	4.9858	0.9533	0.9796	0.9533	0.9796	1.2563
BODY	AR	Spine1	L5S1	0	1.3218	0.6294	1.3216	0.6293	2.0898	-.3310	0.5757	0.5371	1.1270
ROOM	AR	Spine1	L5S1	0	0.8943	2.0071	0.8943	2.0071	1.0023	0.6608	1.0023	0.6608	1.2585
BODY	AR	Spine5	L1L2	0	0.9434	2.1992	0.9435	2.1995	0.9317	1.7178	0.9317	1.7178	1.8846
ROOM	AR	Spine5	L1L2	0	0.9130	6.0914	0.9130	6.0914	0.9377	1.3910	0.9377	1.3910	1.2832
BODY	AR	Spine5	L3L4	0	0.5059	0.4565	0.4750	-.0011	1.1063	-1.414	0.8018	-.6820	1.2241
ROOM	AR	Spine5	L3L4	0	0.9228	1.2426	0.9233	1.2448	0.8186	1.1480	0.9016	1.0893	1.0624
BODY	AR	Spine6	L3L4	0	0.9085	0.8493	0.8861	1.0857	0.8237	-1.670	1.0334	-.6318	1.1212
ROOM	AR	Spine6	L3L4	0	0.9325	-5.064	0.9362	-4.862	0.6551	-.4313	1.3738	-2.969	1.1985
BODY	AR	Spine7	L3L4	0	0.9450	2.6695	0.9448	2.6683	0.7464	-.0318	0.7752	-3.457	1.3780
ROOM	AR	Spine7	L3L4	0	0.9036	-.6304	0.9036	-.6304	0.9928	1.0792	0.9923	1.0452	1.2266
BODY	FE	Spine1	L3L4	0	0.4449	0.2495	0.4455	-.2470	0.8303	1.1962	1.1981	0.4656	1.7599
ROOM	FE	Spine1	L3L4	0	1.1983	-4.164	1.1983	-4.163	0.6741	-.6246	1.4221	-1.626	0.9892
BODY	FE	Spine1	L5S1	0	0.8166	0.8410	0.8706	1.6063	0.9728	1.0489	0.7572	1.0845	1.0790
ROOM	FE	Spine1	L5S1	0	0.3465	-.5138	2.4328	-2.965	0.2157	0.5740	3.0620	2.1203	1.0594
BODY	FE	Spine5	L1L2	0	0.9124	4.1586	0.5367	1.3166	0.7769	0.8189	0.6524	3.2216	1.1263
ROOM	FE	Spine5	L1L2	0	0.7110	-.0148	0.7682	2.4113	0.6968	0.9650	1.0683	1.5933	1.0929
BODY	FE	Spine5	L3L4	0	0.8970	0.1712	1.2142	1.1346	0.8702	1.0996	0.9187	1.0232	1.0232
ROOM	FE	Spine5	L3L4	0	0.3020	0.8941	3.6926	1.1963	1.0526	1.0140	1.1912	0.8576	1.0581
BODY	FE	Spine6	L3L4	0	1.0206	-2.486	0.4863	-.4072	0.9058	-1.445	0.6709	-.5677	1.2947
ROOM	FE	Spine6	L3L4	0	1.1282	0.5082	0.9935	-1.280	1.3619	0.9891	0.8408	0.9477	1.1040
BODY	FE	Spine7	L3L4	0	0.8435	-.6035	0.9533	-1.790	0.7959	1.1596	0.8898	0.5970	1.5543
ROOM	FE	Spine7	L3L4	0	0.7703	-1.810	1.0662	-.6452	2.4330	-2.479	0.4865	-.2934	1.4477
ROOM	LB	Spine1	L3L4	0	0.9471	0.9108	0.9578	1.4243	3.7885	4.5249	0.2186	0.3531	1.0894
BODY	LB	Spine1	L5S1	0	1.1055	1.5777	0.8703	0.8278	0.8196	1.0593	1.3600	0.0245	1.1046
ROOM	LB	Spine1	L5S1	0	0.7059	-1.851	1.7149	-.5892	1.0870	0.9952	0.9741	1.2397	1.0457
BODY	LB	Spine5	L1L2	0	1.1610	1.5752	1.0593	1.2869	0.0620	8.2635	11.931	0.2374	1.1171
ROOM	LB	Spine5	L1L2	0	4.8350	-1.471	0.1955	-1.881	0.7609	1.0117	1.0068	1.3138	1.1148
BODY	LB	Spine5	L3L4	0	0.9752	1.3685	0.9580	1.6630	0.8940	0.9141	1.0125	0.8742	1.0615
ROOM	LB	Spine5	L3L4	0	14.410	1.3518	0.1201	0.8346	0.9376	0.2949	1.4168	1.0046	1.0485
BODY	LB	Spine6	L3L4	0	0.8842	0.7450	0.9908	1.2308	2.0410	-3.948	0.4364	-.3495	1.1513
ROOM	LB	Spine6	L3L4	0	0.9676	0.6412	0.9702	1.2236	0.7801	-.5137	0.9469	-1.897	1.1249

TEMP	DIR	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	LB	Spine7	L3L4	0	2.1459	0.0780	0.7967	-12.35	2.9066	-.5923	0.9429	-121.7	0.7662
ROOM	LB	Spine7	L3L4	0	0.9599	0.4418	0.8469	1.0169	1.2799	0.7565	0.9432	1.0476	1.0803

C.2.4 Loading-Type Targeted Effect Flexibility Parameters

TEMP	DIR	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	AR	Spine1	L3L4	0	1.4942	1.4272	1.2603	0.8434	0.9552	1.0674	0.8452	1.0160	0.9292
ROOM	AR	Spine1	L3L4	0	1.2563	2.5535	2.4481	1.9487	2.0326	2.0785	0.8683	0.8374	0.8528
BODY	AR	Spine1	L5S1	0	1.1270	1.6919	1.3390	1.1881	1.5013	0.9113	0.6748	0.6774	0.6760
ROOM	AR	Spine1	L5S1	0	1.2585	1.4608	1.3438	1.0677	1.1607	1.1762	0.8895	0.7937	0.8377
BODY	AR	Spine5	L1L2	0	1.8846	3.5544	3.4083	1.8084	1.8860	1.9440	0.5656	0.5728	0.5692
ROOM	AR	Spine5	L1L2	0	1.2832	2.7146	2.5960	2.0231	2.1155	2.1902	0.8564	0.8338	0.8451
BODY	AR	Spine5	L3L4	0	1.2241	2.8387	2.6972	2.2034	2.3190	2.3342	0.5547	0.7940	0.6653
ROOM	AR	Spine5	L3L4	0	1.0624	1.1103	1.1533	1.0856	1.0451	1.2384	1.0201	1.0076	1.0129
BODY	AR	Spine6	L3L4	0	1.1212	1.3852	1.2701	1.1328	1.2354	1.1945	0.8592	0.8872	0.8740
ROOM	AR	Spine6	L3L4	0	1.1985	1.8497	1.2420	1.0363	1.5434	1.1501	0.8934	0.9977	0.9448
BODY	AR	Spine7	L3L4	0	1.3780	1.9959	1.7911	1.2997	1.4484	1.2146	0.7755	0.6643	0.7197
ROOM	AR	Spine7	L3L4	0	1.2266	2.2706	2.2095	1.8013	1.8511	1.8683	0.9068	0.8256	0.8666
BODY	FE	Spine1	L3L4	0	1.7599	1.7587	1.4231	0.8086	0.9993	0.8480	0.5374	0.6312	0.5838
ROOM	FE	Spine1	L3L4	0	0.9892	1.6490	1.4142	1.4296	1.6670	1.3232	0.8490	0.8501	0.8497
BODY	FE	Spine1	L5S1	0	1.0790	1.4147	1.3324	1.2348	1.3111	1.4042	1.0539	1.0365	1.0476
ROOM	FE	Spine1	L5S1	0	1.0594	1.2673	1.1402	1.0762	1.1962	1.2191	1.0722	0.8329	0.9757
BODY	FE	Spine5	L1L2	0	1.1263	1.5408	1.1984	1.0640	1.3680	1.4396	1.7342	0.7990	1.0278
ROOM	FE	Spine5	L1L2	0	1.0929	2.4500	1.6314	1.4927	2.2418	2.1403	1.0917	1.5932	1.3838
BODY	FE	Spine5	L3L4	0	1.0232	1.4157	1.2098	1.1824	1.3836	1.1554	0.9111	1.1001	1.0101
ROOM	FE	Spine5	L3L4	0	1.0581	0.9257	0.7237	0.6839	0.8749	0.6098	0.8526	0.8561	0.8544
BODY	FE	Spine6	L3L4	0	1.2947	1.4478	1.3181	1.0180	1.1183	0.9649	0.6425	0.6170	0.6298
ROOM	FE	Spine6	L3L4	0	1.1040	1.8005	1.7418	1.5777	1.6309	1.7577	1.1824	0.9156	1.0642
BODY	FE	Spine7	L3L4	0	1.5543	1.9008	1.6898	1.0872	1.2229	1.1705	0.6373	0.5814	0.6085
ROOM	FE	Spine7	L3L4	0	1.4477	1.9923	1.8671	1.2897	1.3762	1.2416	0.7141	0.7537	0.7335
ROOM	LB	Spine1	L3L4	0	1.0894	1.5180	1.3143	1.2064	1.3934	1.3579	1.0401	0.9556	1.0004
BODY	LB	Spine1	L5S1	0	1.1046	1.3636	1.0652	0.9643	1.2344	1.1755	1.0899	1.3109	1.1786
ROOM	LB	Spine1	L5S1	0	1.0457	1.4011	1.3300	1.2719	1.3398	1.3282	1.0723	0.9529	1.0293
BODY	LB	Spine5	L1L2	0	1.1171	1.5606	1.2184	1.0907	1.3970	1.5277	1.4533	1.0184	1.1313
ROOM	LB	Spine5	L1L2	0	1.1148	1.6412	1.2760	1.1446	1.4722	1.3433	1.0159	1.1626	1.0809
BODY	LB	Spine5	L3L4	0	1.0615	1.1893	1.0987	1.0351	1.1204	1.0970	1.1201	0.9792	1.0447
ROOM	LB	Spine5	L3L4	0	1.0485	1.2410	1.1375	1.0849	1.1836	1.2261	1.5100	2.3732	1.9660
BODY	LB	Spine6	L3L4	0	1.1513	1.3429	1.1888	1.0325	1.1664	1.1338	0.8739	0.9075	0.8902
ROOM	LB	Spine6	L3L4	0	1.1249	1.4396	1.2217	1.0861	1.2798	1.1413	0.9007	0.8306	0.8642

TEMP	DIR	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	LB	Spine7	L3L4	0	0.7662	2.7792	3.1718	4.1397	3.6273	5.9917	1.5044	2.4999	2.0012
ROOM	LB	Spine7	L3L4	0	1.0803	1.4518	1.2877	1.1920	1.3439	1.2241	0.7741	0.8910	0.8408

C.2.5. Temperature-Targeted Effect DIP-Boltzmann Parameters

TEMP	DIR	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	AR	Spine1	L3L4	0	1.3004	0.4651	1.3004	0.4651	1.5653	-2.263	1.5653	-2.263	0.5985
ROOM	AR	Spine1	L3L4	1	1.1182	0.3392	1.1182	0.3392	1.0799	0.4368	1.0799	0.4368	0.7119
ROOM	AR	Spine1	L5S1	0	0.9719	1.2069	0.9720	1.2072	0.8309	0.5329	0.8309	0.5329	0.6239
ROOM	AR	Spine1	L5S1	1	1.4365	0.3785	1.4364	0.3785	1.7325	-.2669	0.4772	0.4331	0.5587
ROOM	AR	Spine5	L1L2	0	0.9547	0.6550	0.9546	0.6549	1.0107	0.8359	1.0107	0.8359	0.5108
ROOM	AR	Spine5	L1L2	1	0.9865	0.2365	0.9865	0.2365	1.0043	1.0323	1.0043	1.0323	0.7502
ROOM	AR	Spine5	L3L4	0	0.9603	0.1146	0.8529	54.826	0.7486	-.9120	1.1133	-1.593	0.8590
ROOM	AR	Spine5	L3L4	1	0.5265	0.0421	0.4388	-.0467	1.0116	1.1234	0.9901	0.9973	0.9898
ROOM	AR	Spine6	L3L4	0	0.7198	-.2016	0.5018	0.0958	0.7975	-.3695	0.8322	-1.637	0.8478
ROOM	AR	Spine6	L3L4	1	0.7013	0.0338	0.4750	-.0214	1.0029	-1.431	0.6260	-.3483	0.7931
ROOM	AR	Spine7	L3L4	0	1.0038	0.1846	1.0040	0.1847	0.6500	-12.19	0.9862	0.4004	0.6838
ROOM	AR	Spine7	L3L4	1	1.0498	-.7820	1.0498	-.7820	0.4887	0.3597	0.7704	-1.324	0.7682
ROOM	FE	Spine1	L3L4	0	1.4342	-2.368	1.4342	-2.368	0.8503	-.4982	1.2909	-5.066	0.4329
ROOM	FE	Spine1	L3L4	1	0.5325	0.1419	0.5332	-.1405	1.0474	0.9540	1.0875	1.4510	0.7701
ROOM	FE	Spine1	L5S1	0	0.6422	-.6814	2.5783	-1.117	0.3574	0.6606	3.8892	2.2526	0.7549
ROOM	FE	Spine1	L5S1	1	1.5133	1.1152	0.9227	0.6048	1.6121	1.2072	0.9617	1.1522	0.7689
ROOM	FE	Spine5	L1L2	0	1.1194	0.0110	1.2206	0.5094	1.4011	1.0074	3.6125	0.6849	0.8612
ROOM	FE	Spine5	L1L2	1	1.4365	-3.087	0.8528	0.2781	1.5623	0.8549	2.2062	1.3847	0.8875
ROOM	FE	Spine5	L3L4	0	1.1903	5.3171	0.9611	1.0502	1.3149	1.0169	1.4018	0.6616	1.0476
ROOM	FE	Spine5	L3L4	1	3.5349	1.0184	0.3160	0.9960	1.0871	1.1027	1.0811	0.7893	1.0130
ROOM	FE	Spine6	L3L4	0	3.2981	-.1322	0.9861	-.3885	5.1756	0.5315	0.8523	-.9690	2.1744
ROOM	FE	Spine6	L3L4	1	2.9836	0.6467	0.4827	-.1236	3.4422	-.7765	0.6801	0.5805	2.5500
ROOM	FE	Spine7	L3L4	0	1.0016	-1.548	1.2220	-.5801	1.5381	0.8840	1.0966	1.0065	0.5748
ROOM	FE	Spine7	L3L4	1	1.0967	-.5164	1.0927	-1.609	0.5031	-.4136	2.0055	-2.048	0.6171
ROOM	LB	Spine1	L3L4	1	1.8645	-1.164	0.8880	-1.232	0.7385	0.3002	2.4178	-5.021	0.9624
ROOM	LB	Spine1	L5S1	0	1.1685	0.7896	1.0040	0.5523	1.1106	0.6906	0.8128	112.98	0.6128
ROOM	LB	Spine1	L5S1	1	1.8300	-.6731	0.5095	-.7760	0.8374	0.7351	1.1347	2.2372	0.6474
ROOM	LB	Spine5	L1L2	0	0.2514	-.2774	0.8511	0.6047	4.7197	0.7161	0.0805	5.3942	0.7550
ROOM	LB	Spine5	L1L2	1	0.0604	0.2971	4.6121	-.4137	0.3847	5.8492	0.9538	0.9746	0.7565
ROOM	LB	Spine5	L3L4	0	3.5971	6.3658	1.1857	1.3810	1.0745	-.1186	3.3725	-1.403	0.9427
ROOM	LB	Spine5	L3L4	1	0.2434	6.4443	9.4571	2.7519	1.0246	-.3675	2.4101	-1.221	0.9543
ROOM	LB	Spine6	L3L4	0	0.6977	0.6906	0.9778	1.0085	0.5625	-.4575	1.0521	-2.355	0.8677
ROOM	LB	Spine6	L3L4	1	0.6376	0.8025	0.9985	1.0144	1.4715	-3.516	0.4849	-.4338	0.8881

TEMP	DIR	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	LB	Spine7	L3L4	0	1.1443	-44.63	1.1987	0.9579	1.0641	1.0809	0.8938	0.9220	0.8412
ROOM	LB	Spine7	L3L4	1	2.5580	-7.884	1.1276	-11.64	2.4166	-.8464	0.8936	-107.1	0.5966

C.2.6. Temperature-Targeted Effect Flexibility Parameters

TEMP	DIR	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	AR	Spine1	L3L4	0	0.5985	0.5318	0.6171	1.0311	0.8884	0.7899	1.2851	1.0676	1.1681
ROOM	AR	Spine1	L3L4	1	0.7119	0.2972	0.3177	0.4463	0.4175	0.4056	1.2509	1.2953	1.2727
ROOM	AR	Spine1	L5S1	0	0.6239	0.5005	0.4733	0.7586	0.8022	0.8392	1.6367	1.9145	1.7683
ROOM	AR	Spine1	L5S1	1	0.5587	0.5797	0.4716	0.8442	1.0376	0.6502	1.2417	1.6340	1.4271
ROOM	AR	Spine5	L1L2	0	0.5108	0.3749	0.3728	0.7299	0.7340	0.7391	2.0429	1.9296	1.9853
ROOM	AR	Spine5	L1L2	1	0.7502	0.4909	0.4894	0.6524	0.6544	0.6560	1.3493	1.3255	1.3373
ROOM	AR	Spine5	L3L4	0	0.8590	0.2773	0.5332	0.6208	0.3228	0.5847	1.2610	1.3955	1.3352
ROOM	AR	Spine5	L3L4	1	0.9898	0.7090	1.2470	1.2599	0.7163	1.1020	0.6857	1.0996	0.8771
ROOM	AR	Spine6	L3L4	0	0.8478	0.7611	0.8215	0.9690	0.8978	0.8736	1.0181	0.9547	0.9841
ROOM	AR	Spine6	L3L4	1	0.7931	0.5700	0.8401	1.0592	0.7187	0.9073	0.9791	0.8490	0.9104
ROOM	AR	Spine7	L3L4	0	0.6838	0.3808	0.3904	0.5710	0.5568	0.5931	1.4339	1.4815	1.4559
ROOM	AR	Spine7	L3L4	1	0.7682	0.3347	0.3165	0.4120	0.4357	0.3856	1.2262	1.1921	1.2091
ROOM	FE	Spine1	L3L4	0	0.4329	0.4180	0.5860	1.3538	0.9657	1.0277	1.6199	2.0361	1.8428
ROOM	FE	Spine1	L3L4	1	0.7701	0.4458	0.5897	0.7657	0.5789	0.6586	1.0253	1.5118	1.2663
ROOM	FE	Spine1	L5S1	0	0.7549	0.7137	0.8674	1.1490	0.9454	0.9185	1.3227	1.2243	1.2871
ROOM	FE	Spine1	L5S1	1	0.7689	0.7968	1.0136	1.3183	1.0363	1.0580	1.3001	1.5237	1.3819
ROOM	FE	Spine5	L1L2	0	0.8612	0.5018	0.8611	0.9999	0.5827	0.5754	0.8850	1.2672	1.1094
ROOM	FE	Spine5	L1L2	1	0.8875	0.3156	0.6325	0.7127	0.3556	0.3870	1.4058	0.6355	0.8240
ROOM	FE	Spine5	L3L4	0	1.0476	0.6143	0.5163	0.4929	0.5865	0.4310	0.8814	0.7470	0.8047
ROOM	FE	Spine5	L3L4	1	1.0130	0.9395	0.8632	0.8522	0.9275	0.8167	0.9419	0.9599	0.9513
ROOM	FE	Spine6	L3L4	0	2.1744	2.2218	5.5690	2.5612	1.0218	0.7742	0.1423	0.0928	0.1183
ROOM	FE	Spine6	L3L4	1	2.5500	1.7866	4.2142	1.6526	0.7006	0.4250	0.0773	0.0625	0.0700
ROOM	FE	Spine7	L3L4	0	0.5748	0.5130	0.6177	1.0746	0.8925	0.8518	1.6576	1.7337	1.6950
ROOM	FE	Spine7	L3L4	1	0.6171	0.4895	0.5590	0.9058	0.7931	0.8030	1.4792	1.3373	1.4062
ROOM	LB	Spine1	L3L4	1	0.9624	0.6875	1.1350	1.1793	0.7144	0.6849	0.9459	0.7039	0.8143
ROOM	LB	Spine1	L5S1	0	0.6128	0.7401	0.8987	1.4665	1.2077	1.1739	1.1244	0.6971	0.9336
ROOM	LB	Spine1	L5S1	1	0.6474	0.7203	0.7198	1.1119	1.1127	1.0390	1.1429	0.9591	1.0691
ROOM	LB	Spine5	L1L2	0	0.7550	0.5431	0.4338	0.5746	0.7193	0.5007	0.9152	0.4166	0.5828
ROOM	LB	Spine5	L1L2	1	0.7565	0.5164	0.4142	0.5475	0.6826	0.5695	1.3093	0.3649	0.6100
ROOM	LB	Spine5	L3L4	0	0.9427	0.8631	1.2173	1.2913	0.9156	1.0652	1.2679	2.2201	1.7453
ROOM	LB	Spine5	L3L4	1	0.9543	0.8271	1.1757	1.2320	0.8667	0.9530	0.9405	0.9161	0.9274
ROOM	LB	Spine6	L3L4	0	0.8677	0.7476	0.5778	0.6659	0.8615	0.8242	0.9922	1.0220	1.0069
ROOM	LB	Spine6	L3L4	1	0.8881	0.6974	0.5622	0.6331	0.7852	0.8187	0.9627	1.1167	1.0372

TEMP	DIR	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	LB	Spine7	L3L4	0	0.8412	0.6927	0.7208	0.8569	0.8235	0.7559	1.2290	1.1355	1.1707
ROOM	LB	Spine7	L3L4	1	0.5966	1.3261	1.7753	2.9759	2.2228	3.7000	2.3885	3.1858	2.7864

C.3. Dynamic Loading Tests

C.3.1. DIP-Boltzmann Parameters

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine1	L1L2	0.25	0.6061	0.8813	2.9393	-.0058	0.5920	2.1409	2.5956	0.6734	11.609
ROOM	FE	Spine1	L1L2	0.5	3.0006	0.0174	0.6107	0.8853	0.5983	2.1060	2.6131	0.6738	11.492
ROOM	FE	Spine1	L1L2	0.5	3.0460	-.0114	0.6127	0.9062	0.5868	2.1262	2.7142	0.7014	11.511
ROOM	FE	Spine1	L1L2	1	3.0115	0.0535	0.6151	0.8596	0.6048	2.0997	2.4658	0.7032	11.371
ROOM	FE	Spine1	L1L2	1	3.1853	-.0139	0.6260	0.7892	0.6159	2.1192	3.4247	0.5623	11.458
ROOM	FE	Spine1	L1L2	1	3.0189	-.0048	0.6095	0.8938	0.6037	2.1734	2.6079	0.6659	11.461
ROOM	FE	Spine1	L1L2	2	2.9633	0.0091	0.6194	0.8491	0.6204	2.1952	2.7128	0.6267	11.370
ROOM	FE	Spine1	L1L2	2	3.0419	-.0252	0.6341	0.7901	2.7162	0.5084	0.6464	2.1831	11.393
ROOM	FE	Spine1	L1L2	4	2.7727	-.0612	0.6502	0.8812	0.6078	2.2157	2.9339	0.6401	11.296
ROOM	FE	Spine1	L1L2	4	2.7683	-.0308	0.6390	0.7507	0.6073	2.1663	2.8261	0.5913	11.339
ROOM	FE	Spine1	L1L2	6	3.1395	-.0099	0.6075	0.6210	0.6151	2.2137	2.7124	0.6037	11.247
ROOM	FE	Spine1	L1L2	6	3.2181	0.0149	0.6128	0.6656	0.6067	2.1232	2.6077	0.7172	11.258
ROOM	FE	Spine1	L1L2	8	3.2065	-.0565	0.6144	0.6278	0.6343	2.3300	2.5791	0.5965	11.218
ROOM	FE	Spine1	L1L2	8	6.4757	0.0180	0.6290	0.4388	0.6883	2.6704	2.6049	0.3171	11.240
ROOM	FE	Spine1	L1L2	10	3.2072	-.0588	0.6017	0.5421	0.6376	2.3185	2.6037	0.5847	11.247
ROOM	FE	Spine1	L1L2	10	3.1712	-.1096	0.6062	0.5504	0.6159	2.3392	2.9322	0.5791	11.285
ROOM	FE	Spine1	L1L2	12	0.6054	0.3524	2.7396	-.0532	0.6149	2.2550	2.7684	0.6911	11.270
ROOM	FE	Spine1	L1L2	12	3.3018	-.1365	0.5820	0.4230	0.6418	2.3588	2.7067	0.6110	11.326
ROOM	FE	Spine1	L1L2	14	3.5808	-.1511	0.5825	0.3618	0.5924	2.3104	2.2976	0.7961	11.380
BODY	FE	Spine1	L3L4	0.5	0.3437	-.5250	0.3437	-.5250	0.3502	1.3097	0.3502	1.3097	3.0982
BODY	FE	Spine1	L3L4	1	0.3125	-.0866	0.3125	-.0866	0.3378	1.7930	0.3378	1.7930	2.7027
BODY	FE	Spine1	L3L4	1	0.3482	-.3183	0.3482	-.3183	0.3487	1.8089	0.3487	1.8089	2.7338
BODY	FE	Spine1	L3L4	2	0.3502	-.3232	0.3502	-.3232	0.3487	1.8585	0.3487	1.8585	2.5924
BODY	FE	Spine1	L3L4	4	0.3469	-.6194	0.3469	-.6194	0.3469	1.8904	0.3469	1.8904	2.3366
BODY	FE	Spine1	L3L4	6	0.3523	-.3097	0.3523	-.3097	0.3263	1.4716	0.3263	1.4716	2.3052
BODY	FE	Spine1	L3L4	8	0.3641	-.9934	0.3641	-.9934	0.3634	1.9739	0.3634	1.9739	2.0204
BODY	FE	Spine1	L3L4	10	0.3502	-.3183	0.3502	-.3183	0.3530	1.9399	0.3530	1.9399	2.1725
BODY	FE	Spine1	L3L4	12	0.3278	-.7062	0.3278	-.7062	0.3414	1.4817	0.3414	1.4817	2.2488
BODY	FE	Spine1	L5S1	0.5	0.3795	-.0226	0.3795	-.0226	0.3267	3.6983	0.3267	3.6983	3.2812
BODY	FE	Spine1	L5S1	1	0.4074	0.4295	0.4074	0.4295	0.3654	3.8203	0.3655	3.8208	3.1282
BODY	FE	Spine1	L5S1	1	0.8353	2.9113	0.5195	-3.033	0.2101	3.9555	0.5582	4.0030	3.1510

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine1	L5S1	2	0.8244	3.0328	0.4904	-2.753	0.3766	4.0341	0.3174	4.0089	3.0996
BODY	FE	Spine1	L5S1	4	0.4057	0.5421	0.4055	0.5398	0.3474	4.0986	0.3475	4.0996	2.8784
BODY	FE	Spine1	L5S1	6	0.3975	0.8343	0.3975	0.8343	0.3857	4.1033	0.3857	4.1033	3.0154
BODY	FE	Spine1	L5S1	8	0.3901	0.0851	0.3901	0.0851	0.3778	3.8642	0.3778	3.8642	2.6239
BODY	FE	Spine1	L5S1	10	0.3444	0.9254	0.3444	0.9254	0.3520	3.8578	0.3520	3.8578	2.8139
BODY	FE	Spine1	L5S1	12	0.3554	1.2480	0.3554	1.2480	0.3669	4.0088	0.3669	4.0088	3.1395
ROOM	FE	Spine2	L1L2	1	1.1852	0.7314	1.1852	0.7314	1.0541	1.6708	1.0541	1.6708	4.9183
ROOM	FE	Spine2	L1L2	2	1.2098	0.7262	1.2098	0.7262	1.0681	1.7023	1.0681	1.7023	4.8822
ROOM	FE	Spine2	L1L2	4	1.1924	0.6696	1.1924	0.6696	1.0611	1.7471	1.0611	1.7471	4.7896
ROOM	FE	Spine2	L1L2	6	1.3106	0.4622	1.3106	0.4622	0.9706	1.7669	0.9706	1.7669	4.5518
ROOM	FE	Spine2	L1L2	6	1.2273	0.6330	1.2273	0.6330	1.0097	1.7764	1.0097	1.7764	4.8133
ROOM	FE	Spine2	L1L2	8	1.1566	0.5715	1.1566	0.5715	0.9631	1.7716	0.9631	1.7716	4.8176
ROOM	FE	Spine2	L1L2	10	1.2589	0.5375	1.2589	0.5375	1.0028	1.7239	1.0028	1.7239	4.7627
ROOM	FE	Spine2	L1L2	10	1.5240	0.6031	1.5240	0.6031	1.2406	1.7748	1.2406	1.7748	4.8631
ROOM	FE	Spine2	L1L2	12	1.3692	0.4868	1.3692	0.4868	1.0130	1.7485	1.0130	1.7485	4.6314
ROOM	FE	Spine2	L1L2	14	1.2692	0.3805	1.2692	0.3805	0.8504	2.0664	0.8504	2.0664	4.7272
ROOM	FE	Spine2	L3L4	0.25	0.6684	-.4802	0.6684	-.4802	1.0397	1.3665	1.0397	1.3665	9.4585
ROOM	FE	Spine2	L3L4	0.5	0.7089	-.3835	0.7089	-.3835	0.9852	1.4081	0.9852	1.4081	9.3077
ROOM	FE	Spine2	L3L4	0.5	0.7216	-.5227	0.7216	-.5227	0.9914	1.3387	0.9914	1.3387	9.3656
ROOM	FE	Spine2	L3L4	1	0.7084	-.2519	0.7084	-.2519	1.0024	1.4452	1.0024	1.4452	9.1436
ROOM	FE	Spine2	L3L4	1	0.7178	-.6635	0.7178	-.6635	1.0426	1.0866	1.0426	1.0866	9.1473
ROOM	FE	Spine2	L3L4	1	0.7392	-.5114	0.7392	-.5114	1.0366	1.3609	1.0366	1.3609	9.2138
ROOM	FE	Spine2	L3L4	2	0.7207	-.6422	0.7207	-.6422	1.0540	1.1032	1.0540	1.1032	9.0322
ROOM	FE	Spine2	L3L4	2	0.7152	-.5727	0.7152	-.5727	1.0341	1.3288	1.0341	1.3288	9.0909
ROOM	FE	Spine2	L3L4	4	0.7195	-.6805	0.7195	-.6805	1.0294	1.1599	1.0294	1.1599	8.9995
ROOM	FE	Spine2	L3L4	4	0.6941	-.6198	0.6941	-.6198	1.0032	1.3268	1.0032	1.3268	9.0266
ROOM	FE	Spine2	L3L4	6	0.7050	-.6971	0.7050	-.6971	1.0209	1.1446	1.0209	1.1446	8.9150
ROOM	FE	Spine2	L3L4	6	0.6808	-.6571	0.6808	-.6571	0.9711	1.3493	0.9711	1.3493	8.9559
ROOM	FE	Spine2	L3L4	8	0.7056	-.7599	0.7056	-.7599	0.9645	1.1509	0.9645	1.1509	8.8781
ROOM	FE	Spine2	L3L4	8	0.7007	-.7063	0.7007	-.7063	0.9581	1.2195	0.9581	1.2195	8.9476
ROOM	FE	Spine2	L3L4	10	0.6984	-.7272	0.6984	-.7272	0.9951	1.2286	0.9951	1.2286	8.8425
ROOM	FE	Spine2	L3L4	10	0.6913	-.7399	0.6913	-.7399	0.9725	1.2461	0.9725	1.2461	8.9366
ROOM	FE	Spine2	L3L4	12	0.7350	-.7412	0.7350	-.7412	0.9351	1.2679	0.9351	1.2679	8.8998

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine2	L3L4	12	0.7139	-.7355	0.7139	-.7355	0.8409	1.2184	0.8409	1.2184	8.9010
ROOM	FE	Spine2	L3L4	14	0.7372	-.7654	0.7372	-.7654	0.9738	1.2977	0.9738	1.2977	8.9048
BODY	FE	Spine2	L5S1	0.25	0.5386	1.4973	0.9234	-3.045	0.8671	-.6414	0.6852	4.2888	11.264
BODY	FE	Spine2	L5S1	0.5	0.5461	1.7111	0.9273	-3.065	0.9090	-.7905	0.6823	4.3279	10.824
BODY	FE	Spine2	L5S1	0.5	0.9033	-2.875	0.5508	1.5328	0.7654	4.2976	0.9454	-.7645	10.932
BODY	FE	Spine2	L5S1	1	0.9783	-3.058	0.5542	1.6973	0.6760	4.2016	1.0621	-.8880	10.258
BODY	FE	Spine2	L5S1	1	0.9340	-2.803	0.5614	1.5566	0.7287	4.0452	1.0356	-.7609	10.356
BODY	FE	Spine2	L5S1	1	0.9078	-2.893	0.5685	1.6466	0.7449	4.2213	0.9521	-.7889	10.652
BODY	FE	Spine2	L5S1	2	0.9419	-2.873	0.5860	1.6223	1.0724	-.8183	0.7427	4.0241	10.142
BODY	FE	Spine2	L5S1	2	0.5688	1.6363	0.9000	-2.870	0.7265	4.1076	0.9785	-.8662	10.420
BODY	FE	Spine2	L5S1	4	0.6916	1.8233	0.8523	-2.906	0.7196	4.1292	1.0303	-.8445	10.146
BODY	FE	Spine2	L5S1	6	0.9449	-3.015	0.6363	1.6385	0.7483	4.1265	1.1140	-.8390	9.9453
BODY	FE	Spine2	L5S1	6	0.8411	-3.000	0.6107	1.5100	0.7487	3.9991	1.0608	-.8642	9.9783
BODY	FE	Spine2	L5S1	10	0.6024	1.4531	0.8525	-2.993	0.7921	4.1613	1.0555	-.7448	9.8662
BODY	FE	Spine2	L5S1	10	0.5582	1.8019	0.7782	-2.858	0.8025	4.2123	1.1429	-.8106	9.9093
BODY	FE	Spine2	L5S1	12	0.5801	1.3390	0.8038	-2.990	1.0931	-.7234	0.7955	4.2842	9.7951
BODY	FE	Spine2	L5S1	14	0.8696	-3.100	0.5966	1.4781	0.7964	4.2253	1.0970	-.7178	9.8679
ROOM	FE	Spine3	L1L2	0.25	0.3799	-.6972	1.7139	0.9737	0.4112	2.1067	2.2535	1.6412	9.1642
ROOM	FE	Spine3	L1L2	0.5	0.3868	-.6335	1.7574	0.9550	0.4269	2.0387	2.3207	1.6749	8.9191
ROOM	FE	Spine3	L1L2	0.5	0.3887	-.3084	1.8772	0.9773	2.2564	1.6899	0.4230	2.0670	9.0125
ROOM	FE	Spine3	L1L2	1	1.6301	0.9334	0.4040	-.5804	0.4385	1.8937	1.9600	1.5785	8.6072
ROOM	FE	Spine3	L1L2	1	0.3947	-.5155	1.7396	0.9161	2.2673	1.6708	0.4391	1.9974	8.6946
ROOM	FE	Spine3	L1L2	1	0.3961	-.5047	1.8429	1.1112	2.2093	1.7501	0.4341	2.0130	8.7528
ROOM	FE	Spine3	L1L2	2	1.6694	0.9543	0.4128	-.4977	1.9207	1.6083	0.4526	1.9729	8.4324
ROOM	FE	Spine3	L1L2	2	0.4067	-.4899	1.6019	0.9255	0.4348	1.9660	2.1916	1.7257	8.5099
ROOM	FE	Spine3	L1L2	4	1.6082	0.9793	0.4174	-.3575	2.2078	1.8229	0.4354	1.9774	8.3349
ROOM	FE	Spine3	L1L2	4	1.6840	1.0187	0.4205	-.5684	1.8749	1.7405	0.4377	1.9265	8.3690
ROOM	FE	Spine3	L1L2	6	1.8895	1.0632	0.4093	-.4912	0.4479	2.0959	2.0437	1.8669	8.3112
ROOM	FE	Spine3	L1L2	6	0.4028	-.5520	1.8581	0.9425	0.4537	1.9874	1.7500	1.7252	8.3149
ROOM	FE	Spine3	L1L2	8	0.4100	-.5167	1.8466	0.9074	0.4520	2.0709	1.7809	1.7963	8.2619
ROOM	FE	Spine3	L1L2	8	1.9103	0.9684	0.4132	-.5112	0.4398	2.0022	2.1469	1.9623	8.2718
ROOM	FE	Spine3	L1L2	10	0.4100	-.5450	1.7765	0.9082	0.4550	2.1452	1.8541	1.7827	8.2505
ROOM	FE	Spine3	L1L2	10	0.4142	-.4397	1.8009	0.9360	2.0030	1.8893	0.4487	2.2888	8.2522

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine3	L1L2	12	0.4300	-.6419	1.7875	0.9170	0.4495	2.1633	2.1047	1.8387	8.2314
ROOM	FE	Spine3	L1L2	12	0.4111	-.5688	1.8278	0.9283	2.0156	1.8820	0.4490	2.2333	8.2551
ROOM	FE	Spine3	L1L2	14	0.4104	-.5994	1.9673	0.8611	0.4682	2.2860	1.9103	1.8800	8.2639
BODY	FE	Spine3	L5S1	0.25	6.0702	-.5441	0.6887	-.7128	0.6110	1.4408	5.7434	1.3055	18.449
BODY	FE	Spine3	L5S1	0.5	6.6018	-.4422	0.7319	-.5887	0.6358	1.3314	4.8989	1.3606	17.917
BODY	FE	Spine3	L5S1	0.5	6.3648	-.6330	0.7288	-.7504	5.6150	1.2394	0.6302	1.2524	18.325
BODY	FE	Spine3	L5S1	1	6.5693	-.3500	0.7684	-.5133	0.6403	1.3640	5.2394	1.4279	17.436
BODY	FE	Spine3	L5S1	1	7.8988	-1.365	0.8350	-1.439	0.7434	0.5045	4.0465	0.2061	17.849
BODY	FE	Spine3	L5S1	1	7.1777	-.6475	0.7667	-.7765	0.6835	1.0924	5.8468	1.1264	18.032
BODY	FE	Spine3	L5S1	2	8.5395	-.7133	0.8250	-.7728	5.1086	1.1261	0.6979	1.0826	17.853
BODY	FE	Spine3	L5S1	4	0.8311	-1.329	6.9238	-1.339	3.7359	0.2482	0.7593	0.6212	17.640
BODY	FE	Spine3	L5S1	4	0.8117	-.8963	9.0018	-.7941	4.6652	0.9827	0.6940	1.0264	17.848
BODY	FE	Spine3	L5S1	6	6.7381	-1.328	0.8111	-1.374	3.6049	0.3158	0.7482	0.5837	17.647
BODY	FE	Spine3	L5S1	6	5.6998	-.9085	0.8351	-1.030	0.7096	1.0137	4.3276	0.8753	17.665
BODY	FE	Spine3	L5S1	8	6.6806	-1.242	0.8336	-1.391	3.3419	0.3351	0.8273	0.6619	17.622
BODY	FE	Spine3	L5S1	8	7.8969	-.9858	0.8288	-1.186	4.5014	0.7809	0.7285	0.9318	17.626
BODY	FE	Spine3	L5S1	10	7.0107	-1.080	0.8287	-1.187	0.7303	0.9270	4.3090	0.6998	17.586
BODY	FE	Spine3	L5S1	10	0.8438	-1.333	6.1039	-1.249	0.7911	0.8368	3.4827	0.3513	17.684
BODY	FE	Spine3	L5S1	12	7.3896	-1.248	0.8619	-1.358	0.7698	0.8474	5.0825	0.3839	17.509
BODY	FE	Spine3	L5S1	12	0.8243	-1.420	8.3713	-1.120	4.3973	0.5466	0.7560	1.0289	17.521
BODY	FE	Spine3	L5S1	14	5.6881	-1.230	0.8310	-1.350	4.2942	0.5315	0.7608	0.9482	17.542
BODY	FE	Spine4	L1L2	0.25	1.2894	1.3392	1.2894	1.3392	1.5221	1.8918	1.5221	1.8918	11.182
BODY	FE	Spine4	L1L2	0.5	1.7887	1.1439	1.7887	1.1439	1.7547	1.9078	1.7547	1.9078	10.850
BODY	FE	Spine4	L1L2	0.5	1.8005	1.0614	1.8005	1.0614	1.6643	1.8913	1.6643	1.8913	11.070
BODY	FE	Spine4	L1L2	1	1.7570	1.1769	1.7570	1.1769	1.4913	1.9448	1.4913	1.9448	10.651
BODY	FE	Spine4	L1L2	1	1.8505	1.0202	1.8505	1.0202	1.5038	1.8188	1.5038	1.8188	10.809
BODY	FE	Spine4	L1L2	1	1.8904	1.0810	1.8904	1.0810	1.6457	1.8942	1.6457	1.8942	10.880
BODY	FE	Spine4	L1L2	2	1.7443	1.0229	1.7443	1.0229	1.5472	1.8473	1.5472	1.8473	10.643
BODY	FE	Spine4	L1L2	2	1.7652	1.0726	1.7652	1.0726	1.5050	1.8911	1.5050	1.8911	10.727
BODY	FE	Spine4	L1L2	4	1.7160	1.0456	1.7160	1.0456	1.4316	1.9053	1.4316	1.9053	10.477
BODY	FE	Spine4	L1L2	4	1.7812	1.0270	1.7812	1.0270	1.4873	1.8461	1.4873	1.8461	10.603
BODY	FE	Spine4	L1L2	6	1.6048	1.1429	1.6048	1.1429	1.4062	1.9742	1.4062	1.9742	10.437
BODY	FE	Spine4	L1L2	6	1.6348	1.0684	1.6348	1.0684	1.3292	1.9550	1.3292	1.9550	10.475

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine4	L1L2	8	1.6823	1.1003	1.6823	1.1003	1.3901	1.9614	1.3901	1.9614	10.428
BODY	FE	Spine4	L1L2	8	1.6806	1.0897	1.6806	1.0897	1.3892	1.9566	1.3892	1.9565	10.440
BODY	FE	Spine4	L1L2	10	1.5698	1.0873	1.5698	1.0873	1.3565	2.0051	1.3565	2.0051	10.371
BODY	FE	Spine4	L1L2	10	1.7394	1.0725	1.7394	1.0725	1.4561	1.9718	1.4561	1.9718	10.440
BODY	FE	Spine4	L1L2	12	1.7860	1.0550	1.7860	1.0550	1.3748	2.0049	1.3748	2.0049	10.433
BODY	FE	Spine4	L1L2	12	1.7360	1.0235	1.7360	1.0235	1.4038	1.9609	1.4038	1.9609	10.452
BODY	FE	Spine4	L1L2	14	1.7677	1.0338	1.7677	1.0338	1.4215	2.0075	1.4215	2.0075	10.299
ROOM	FE	Spine4	L5S1	0.25	0.9438	0.2635	7.3832	-.0780	1.4589	1.4277	9.4722	1.2188	16.957
ROOM	FE	Spine4	L5S1	0.5	6.0272	-.0961	1.0098	0.3042	14.643	1.5457	1.1818	1.6732	16.751
ROOM	FE	Spine4	L5S1	0.5	0.9833	0.3267	5.2077	-.0305	8.3205	1.2689	1.5000	1.4605	16.799
ROOM	FE	Spine4	L5S1	1	3.5997	0.0746	0.7288	0.0554	1.6295	1.4691	9.5434	1.1309	14.833
ROOM	FE	Spine4	L5S1	1	6.0849	-.1314	1.0396	0.3347	1.4988	1.4529	9.7940	1.1888	16.656
ROOM	FE	Spine4	L5S1	1	0.9821	0.3838	6.1768	0.0514	8.2025	1.3257	1.4615	1.4899	16.749
ROOM	FE	Spine4	L5S1	2	1.0387	0.3067	6.1230	-.1448	1.2750	1.2564	6.3420	1.2561	16.566
ROOM	FE	Spine4	L5S1	4	1.0358	0.2114	5.3232	-.1692	1.3659	1.4021	9.0042	1.2049	16.432
ROOM	FE	Spine4	L5S1	6	8.1020	-.2157	1.1202	0.2969	5.9153	1.3368	0.9297	0.7694	16.380
ROOM	FE	Spine4	L5S1	6	1.0266	0.1863	5.7112	-.2087	1.3739	1.2636	4.6712	1.3061	16.441
ROOM	FE	Spine4	L5S1	8	1.0930	0.2792	6.0265	-.1964	8.0121	1.2416	1.3541	1.4379	16.357
ROOM	FE	Spine4	L5S1	8	0.9651	-.0704	4.0727	-.1470	2.9042	1.1325	1.6332	1.5821	16.379
ROOM	FE	Spine4	L5S1	10	1.1408	0.1926	5.4109	-.1381	1.2428	1.5130	6.0762	1.1755	16.360
ROOM	FE	Spine4	L5S1	10	1.3311	0.4438	3.0133	-.5259	5.5181	1.3005	1.2865	1.5010	16.387
ROOM	FE	Spine4	L5S1	12	1.0878	0.2397	5.9063	-.2570	1.3303	1.6294	8.9862	1.2198	16.280
ROOM	FE	Spine4	L5S1	12	0.9709	-.1803	4.2621	-.0286	1.2493	1.3094	4.2603	1.5051	16.418
ROOM	FE	Spine4	L5S1	14	0.9591	0.0893	5.6408	-.1028	1.2667	1.7275	6.9666	1.3153	16.452
BODY	FE	Spine5	L1L2	0.25	3.4782	-1.220	0.4859	-3.022	0.4601	-.1200	4.4260	-.5036	4.3976
BODY	FE	Spine5	L1L2	0.5	3.4400	-1.239	0.5069	-3.282	4.3263	-.5489	0.4114	-.2615	4.3736
BODY	FE	Spine5	L1L2	1	3.2374	-1.152	0.5494	-3.341	0.4712	-.2771	4.5763	-.6288	4.1545
BODY	FE	Spine5	L1L2	1	2.8015	-1.167	0.5737	-3.377	0.4675	-.0939	5.3736	-.6917	4.2039
BODY	FE	Spine5	L1L2	2	3.6017	-1.120	0.4861	-3.178	0.4593	-.0422	3.9994	-.6624	4.1986
BODY	FE	Spine5	L1L2	4	3.1970	-.9840	0.4970	-3.253	0.4892	-.6333	3.0497	-.7606	4.0992
ROOM	FE	Spine5	L3L4	0.5	0.8870	0.9948	0.8870	0.9948	0.8593	1.8210	0.8593	1.8210	18.979
ROOM	FE	Spine5	L3L4	1	0.9405	0.9878	0.9405	0.9878	0.8869	1.6835	0.8869	1.6835	18.666
ROOM	FE	Spine5	L3L4	1	0.8903	0.9567	0.8903	0.9567	0.8868	1.8185	0.8868	1.8185	18.774

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine5	L3L4	2	0.8983	1.0435	0.8983	1.0435	0.8505	1.7371	0.8505	1.7371	18.674
ROOM	FE	Spine5	L3L4	4	0.9752	0.8691	0.9752	0.8691	0.8580	1.9130	0.8580	1.9130	18.446
ROOM	FE	Spine5	L3L4	6	0.9524	0.9733	0.9524	0.9733	0.8735	1.7573	0.8735	1.7573	18.372
ROOM	FE	Spine5	L3L4	8	1.0408	0.5663	1.0408	0.5663	0.8634	2.3146	0.8634	2.3146	18.195
ROOM	FE	Spine5	L3L4	10	0.9160	0.9936	0.9160	0.9936	0.8430	1.7169	0.8430	1.7169	18.407
ROOM	FE	Spine5	L3L4	12	0.8866	1.2760	0.8866	1.2760	0.8606	1.5090	0.8606	1.5090	18.513
BODY	FE	Spine6	L3L4	0.5	0.2734	-1.478	0.2734	-1.478	0.2825	1.2823	0.2825	1.2823	3.9071
BODY	FE	Spine6	L3L4	1	0.2811	-1.343	0.2811	-1.343	0.2861	1.4144	0.2861	1.4144	3.6069
BODY	FE	Spine6	L3L4	2	0.2793	-1.531	0.2793	-1.531	0.2807	1.3008	0.2807	1.3008	3.5061
BODY	FE	Spine6	L3L4	4	0.2867	-1.896	0.2867	-1.896	0.2967	1.2487	0.2967	1.2487	3.0958
BODY	FE	Spine6	L3L4	6	0.2657	-1.766	0.2657	-1.766	0.2712	1.1752	0.2712	1.1752	3.2885
BODY	FE	Spine6	L3L4	8	0.3287	-1.400	0.3287	-1.400	0.3484	2.2967	0.3484	2.2967	2.4097
BODY	FE	Spine6	L3L4	10	0.2757	-1.452	0.2757	-1.452	0.2961	1.3460	0.2961	1.3460	3.1219
BODY	FE	Spine6	L3L4	12	0.2626	-1.591	0.2626	-1.591	0.2706	1.3320	0.2706	1.3320	3.3706
BODY	FE	Spine7	L1L2	0.25	1.1089	3.1663	0.3896	-1.187	1.4886	4.5758	0.4583	2.1818	7.5542
BODY	FE	Spine7	L1L2	0.5	0.3845	-.6808	1.2432	3.2297	1.6116	4.5712	0.4512	2.3393	7.1691
BODY	FE	Spine7	L1L2	0.5	0.3963	-1.076	1.1252	3.1740	1.5506	4.5344	0.4497	2.4300	7.3561
BODY	FE	Spine7	L1L2	1	1.3210	3.2737	0.3789	-.2658	1.6907	4.6090	0.4728	2.5559	6.8601
BODY	FE	Spine7	L1L2	1	1.1625	3.1884	0.3816	-.8301	1.5537	4.5408	0.4586	2.4000	7.1143
BODY	FE	Spine7	L1L2	1	0.3852	-1.087	1.1054	3.1230	0.4449	1.7826	1.3807	4.4556	7.3280
BODY	FE	Spine7	L1L2	2	1.2268	3.1668	0.3746	-.6736	0.4449	2.3894	1.5067	4.5569	6.9494
BODY	FE	Spine7	L1L2	2	0.3846	-.7268	1.1881	3.1351	1.3589	4.5661	0.4878	1.9748	7.0086
BODY	FE	Spine7	L1L2	4	1.2571	3.0983	0.3717	-.4162	1.8559	4.6450	0.4775	2.4942	6.6281
BODY	FE	Spine7	L1L2	6	1.3567	2.8420	0.3531	-.1457	0.5125	2.4017	1.2703	4.7416	6.6106
BODY	FE	Spine7	L1L2	6	0.3589	-.2554	1.3411	2.9128	1.3240	4.6265	0.4890	2.3397	6.6457
BODY	FE	Spine7	L1L2	8	1.3001	3.0132	0.3646	-.1749	1.4929	4.6623	0.4504	2.6537	6.6619
BODY	FE	Spine7	L1L2	10	1.1162	3.1867	0.4258	-.3235	1.4250	4.2931	0.4785	2.6678	6.4400
BODY	FE	Spine7	L1L2	10	1.1799	2.8738	0.3460	-.2684	1.3876	4.7017	0.4589	2.4629	6.7170
BODY	FE	Spine7	L1L2	12	0.3465	-.1934	1.2264	2.8184	1.5268	4.4870	0.4158	2.8153	6.6517
BODY	FE	Spine7	L1L2	14	1.2176	2.8136	0.3762	-.2900	0.4812	2.5633	1.4786	4.7282	6.6065
ROOM	FE	Spine7	L5S1	0.25	0.4247	-.5903	1.4180	4.8652	2.0047	6.0455	0.4342	2.2629	8.5619
ROOM	FE	Spine7	L5S1	0.5	0.4312	-.5095	1.4105	4.8568	2.0609	6.0596	0.4508	2.0826	8.3107
ROOM	FE	Spine7	L5S1	0.5	1.4202	4.8586	0.4194	-.4680	0.4372	2.1758	2.0221	6.0565	8.4651

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine7	L5S1	1	0.4431	-.4567	1.3188	4.7939	0.4683	1.9111	2.0860	6.0306	7.9908
ROOM	FE	Spine7	L5S1	1	1.4495	4.8984	0.4358	-.4293	2.0870	6.0191	0.4479	2.2285	8.1841
ROOM	FE	Spine7	L5S1	1	1.3829	4.8350	0.4127	-.3903	0.4411	2.2112	2.0705	6.0487	8.3947
ROOM	FE	Spine7	L5S1	2	1.3480	4.7186	0.4546	-.3478	2.1470	6.0534	0.5144	1.9564	7.8688
ROOM	FE	Spine7	L5S1	2	0.4524	-.3381	1.5039	4.8342	0.4645	2.2405	2.1906	5.9921	8.0107
ROOM	FE	Spine7	L5S1	4	0.4381	-.2710	1.3124	4.7091	2.0990	6.1036	0.4912	2.0354	7.8347
ROOM	FE	Spine7	L5S1	4	0.4528	-.3754	1.4748	4.8427	2.1151	6.0561	0.4562	2.2797	7.9566
ROOM	FE	Spine7	L5S1	6	0.4398	-.4678	1.3915	4.6626	0.4962	1.9884	1.9579	6.1179	7.6688
ROOM	FE	Spine7	L5S1	6	1.4620	4.7223	0.4456	-.4387	2.2527	6.0072	0.4688	2.1990	7.7548
ROOM	FE	Spine7	L5S1	8	1.2641	4.4311	0.4462	-.6912	0.4542	2.0449	1.7529	5.6913	7.2003
ROOM	FE	Spine7	L5S1	8	0.4313	-.6804	1.3052	4.4779	0.4266	2.0675	2.1098	5.7222	7.2163
ROOM	FE	Spine7	L5S1	10	1.4816	4.5161	0.3899	-1.240	1.9990	5.7976	0.3701	1.7039	7.4775
ROOM	FE	Spine7	L5S1	10	0.4182	-.1971	1.3726	4.7442	1.6858	5.8265	0.3781	2.8066	7.8544
ROOM	FE	Spine7	L5S1	12	1.4773	4.5464	0.4530	-.3796	1.6554	5.7591	0.4157	2.6688	7.4098
ROOM	FE	Spine7	L5S1	12	0.4234	-.3050	1.1901	4.5587	1.2890	5.5901	0.3890	2.8928	7.6967
ROOM	FE	Spine7	L5S1	14	0.4305	-.6354	1.2436	4.3019	0.3836	2.7385	1.3134	5.5059	7.3083
ROOM	FE	Spine8	L1L2	0.25	0.4472	-1.726	2.4024	0.2309	0.4245	0.3032	2.7632	1.3808	11.519
ROOM	FE	Spine8	L1L2	0.5	2.5009	0.2788	0.4591	-1.697	2.6513	1.5064	0.4623	0.1434	11.212
ROOM	FE	Spine8	L1L2	0.5	2.4135	0.2089	0.4663	-1.706	2.5540	1.4613	0.4630	0.1300	11.300
ROOM	FE	Spine8	L1L2	1	2.4698	0.3287	0.4660	-1.628	0.4615	0.1810	2.5028	1.5686	11.033
ROOM	FE	Spine8	L1L2	1	2.1093	0.1266	0.4782	-1.795	2.2285	1.3441	0.4613	0.0373	11.142
ROOM	FE	Spine8	L1L2	1	2.3904	0.1961	0.4759	-1.759	2.6285	1.3851	0.4610	0.1246	11.180
ROOM	FE	Spine8	L1L2	2	0.4822	-1.851	2.0910	0.2585	0.4771	-.0722	2.1167	1.4897	10.920
ROOM	FE	Spine8	L1L2	2	0.4727	-1.701	2.3480	0.1494	0.4600	0.1191	2.4572	1.4758	10.981
ROOM	FE	Spine8	L1L2	4	0.4879	-1.677	2.3959	0.1512	0.4537	0.1222	2.9459	1.4885	10.833
ROOM	FE	Spine8	L1L2	6	0.5024	-1.944	1.9836	0.2381	0.4755	0.0660	2.2486	1.6040	10.725
ROOM	FE	Spine8	L1L2	6	2.0971	0.0681	0.4632	-1.673	0.4924	0.1894	2.0790	1.5554	10.777
ROOM	FE	Spine8	L1L2	8	0.4782	-1.854	2.4368	0.0769	0.4687	0.3220	2.5678	1.4501	10.713
ROOM	FE	Spine8	L1L2	10	0.5016	-2.185	2.1056	0.2122	2.1203	1.5746	0.4472	0.2936	10.677
ROOM	FE	Spine8	L1L2	10	2.4036	0.1496	0.4966	-2.049	0.4653	0.2533	2.3723	1.5375	10.780
ROOM	FE	Spine8	L1L2	12	0.4884	-2.130	2.2859	0.0273	0.4632	0.2136	2.0386	1.7039	10.679
ROOM	FE	Spine8	L1L2	14	1.9281	0.0786	0.5220	-2.098	0.4655	0.4742	1.8260	1.6662	10.547
ROOM	FE	Spine8	L3L4	0.25	0.7477	1.4169	0.7477	1.4169	0.8700	2.5201	0.8700	2.5201	11.770

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine8	L3L4	0.5	0.7769	1.4389	0.7769	1.4389	0.8724	2.4971	0.8724	2.4971	11.552
ROOM	FE	Spine8	L3L4	0.5	0.7757	1.4032	0.7757	1.4032	0.8887	2.4843	0.8887	2.4843	11.575
ROOM	FE	Spine8	L3L4	1	0.7879	1.4066	0.7879	1.4066	0.8537	2.5003	0.8537	2.5003	11.404
ROOM	FE	Spine8	L3L4	1	0.7867	1.4584	0.7867	1.4584	0.8740	2.5257	0.8740	2.5257	11.411
ROOM	FE	Spine8	L3L4	1	0.7684	1.1995	0.7684	1.1995	0.8482	2.2452	0.8482	2.2452	11.513
ROOM	FE	Spine8	L3L4	2	0.7801	1.3944	0.7801	1.3944	0.8457	2.4799	0.8457	2.4799	11.347
ROOM	FE	Spine8	L3L4	2	0.7777	1.2195	0.7777	1.2195	0.8511	2.2764	0.8511	2.2764	11.433
ROOM	FE	Spine8	L3L4	4	0.7822	1.3595	0.7822	1.3595	0.8620	2.4977	0.8620	2.4977	11.249
ROOM	FE	Spine8	L3L4	6	0.7808	1.3140	0.7808	1.3140	0.8501	2.4780	0.8501	2.4780	11.170
ROOM	FE	Spine8	L3L4	6	0.7782	1.1898	0.7782	1.1898	0.8313	2.3580	0.8313	2.3580	11.282
ROOM	FE	Spine8	L3L4	8	0.7843	1.2402	0.7843	1.2402	0.8575	2.4661	0.8575	2.4661	11.164
ROOM	FE	Spine8	L3L4	10	0.7861	1.1591	0.7861	1.1591	0.8536	2.4437	0.8536	2.4437	11.131
ROOM	FE	Spine8	L3L4	10	0.7727	1.2253	0.7727	1.2253	0.8613	2.5143	0.8613	2.5143	11.206
ROOM	FE	Spine8	L3L4	12	0.7898	1.1860	0.7898	1.1860	0.8462	2.4942	0.8462	2.4942	11.115
ROOM	FE	Spine8	L3L4	14	0.8025	1.1289	0.8025	1.1289	0.8604	2.5097	0.8604	2.5097	11.102
BODY	FE	Spine8	L5S1	0.25	0.3203	-1.020	0.3203	-1.020	0.3070	1.3804	0.3070	1.3804	4.2828
BODY	FE	Spine8	L5S1	0.5	0.3198	-.9694	0.3198	-.9694	0.3108	1.3726	0.3108	1.3726	3.9851
BODY	FE	Spine8	L5S1	0.5	0.3237	-.9655	0.3237	-.9655	0.3096	1.4222	0.3096	1.4222	4.1175
BODY	FE	Spine8	L5S1	1	0.3377	-1.121	0.3377	-1.121	0.3259	1.0764	0.3259	1.0764	3.3524
BODY	FE	Spine8	L5S1	1	0.3284	-.9978	0.3284	-.9978	0.3219	1.3038	0.3219	1.3038	3.6293
BODY	FE	Spine8	L5S1	1	0.3261	-1.108	0.3261	-1.108	0.3133	1.1251	0.3133	1.1251	3.8564
BODY	FE	Spine8	L5S1	2	0.3418	-1.284	0.3418	-1.284	0.3290	0.8712	0.3290	0.8712	3.1938
BODY	FE	Spine8	L5S1	2	0.3370	-1.099	0.3370	-1.099	0.3231	1.1245	0.3231	1.1245	3.6167
BODY	FE	Spine8	L5S1	4	0.3587	-1.455	0.3587	-1.455	0.3502	0.7765	0.3502	0.7765	2.9315
BODY	FE	Spine8	L5S1	4	0.3344	-1.096	0.3344	-1.096	0.3231	1.2348	0.3231	1.2348	3.4337
BODY	FE	Spine8	L5S1	6	0.3569	-1.184	0.3569	-1.184	0.3554	1.1132	0.3554	1.1132	2.8846
BODY	FE	Spine8	L5S1	6	0.3443	-1.247	0.3443	-1.247	0.3311	1.1952	0.3311	1.1952	3.1977
BODY	FE	Spine8	L5S1	8	0.3516	-1.451	0.3516	-1.451	0.3383	1.0104	0.3383	1.0104	2.8686
BODY	FE	Spine8	L5S1	8	0.3374	-1.445	0.3374	-1.445	0.3322	1.0141	0.3322	1.0141	3.0958
BODY	FE	Spine8	L5S1	10	0.3571	-1.392	0.3571	-1.392	0.3422	1.2347	0.3422	1.2347	2.8100
BODY	FE	Spine8	L5S1	10	0.3596	-1.434	0.3596	-1.434	0.3497	1.0005	0.3497	1.0005	2.9386
BODY	FE	Spine8	L5S1	12	0.3525	-1.340	0.3525	-1.340	0.3376	1.2282	0.3376	1.2282	2.8385

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine8	L5S1	12	0.3467	-1.391	0.3467	-1.391	0.3408	1.1315	0.3408	1.1315	2.9381
BODY	FE	Spine8	L5S1	14	0.3536	-1.355	0.3536	-1.355	0.3400	1.2271	0.3400	1.2271	2.8834

C.3.2. Flexibility Parameters

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine1	L1L2	0.25	11.609	10.996	3.4956	0.3011	0.9472	0.8240	0.2207	0.2716	0.2462
ROOM	FE	Spine1	L1L2	0.5	11.492	10.551	3.4034	0.2961	0.9181	0.8000	0.2180	0.2699	0.2439
ROOM	FE	Spine1	L1L2	0.5	11.511	10.858	3.6168	0.3142	0.9432	0.8360	0.2194	0.2662	0.2428
ROOM	FE	Spine1	L1L2	1	11.371	10.521	3.3354	0.2933	0.9253	0.8100	0.2171	0.2803	0.2487
ROOM	FE	Spine1	L1L2	1	11.458	10.698	3.5526	0.3100	0.9337	0.7200	0.2079	0.2409	0.2244
ROOM	FE	Spine1	L1L2	1	11.461	10.941	3.4916	0.3046	0.9546	0.8320	0.2195	0.2782	0.2489
ROOM	FE	Spine1	L1L2	2	11.370	10.947	3.3798	0.2973	0.9628	0.7960	0.2212	0.2766	0.2489
ROOM	FE	Spine1	L1L2	2	11.393	10.792	3.1977	0.2807	0.9473	0.7520	0.2129	0.2820	0.2475
ROOM	FE	Spine1	L1L2	4	11.296	11.236	3.5628	0.3154	0.9947	0.8260	0.2388	0.2705	0.2547
ROOM	FE	Spine1	L1L2	4	11.339	11.292	3.3680	0.2970	0.9959	0.7860	0.2304	0.2702	0.2503
ROOM	FE	Spine1	L1L2	6	11.247	12.157	3.5945	0.3196	1.0809	0.8580	0.2109	0.2895	0.2502
ROOM	FE	Spine1	L1L2	6	11.258	11.913	3.7778	0.3356	1.0582	0.9040	0.2088	0.2835	0.2462
ROOM	FE	Spine1	L1L2	8	11.218	12.972	3.7913	0.3380	1.1563	0.9520	0.2113	0.3182	0.2647
ROOM	FE	Spine1	L1L2	8	11.240	13.986	3.8889	0.3460	1.2443	0.9260	0.1148	0.4338	0.2743
ROOM	FE	Spine1	L1L2	10	11.247	13.375	3.8540	0.3427	1.1892	0.9620	0.2097	0.3181	0.2639
ROOM	FE	Spine1	L1L2	10	11.285	13.694	4.0660	0.3603	1.2134	0.9720	0.2148	0.3110	0.2629
ROOM	FE	Spine1	L1L2	12	11.270	14.623	4.1367	0.3671	1.2975	1.0320	0.2343	0.2976	0.2660
ROOM	FE	Spine1	L1L2	12	11.326	14.952	4.4120	0.3895	1.3202	1.1040	0.2108	0.3351	0.2730
ROOM	FE	Spine1	L1L2	14	11.380	16.123	4.8564	0.4268	1.4168	1.2780	0.2028	0.3418	0.2723
BODY	FE	Spine1	L3L4	0.5	3.0982	4.8905	0.4893	0.1579	1.5785	1.8340	3.7796	3.7094	3.7445
BODY	FE	Spine1	L3L4	1	2.7027	4.2916	0.4156	0.1538	1.5879	1.8780	4.7636	4.4067	4.5851
BODY	FE	Spine1	L3L4	1	2.7338	4.9856	0.5009	0.1832	1.8237	2.1300	4.2366	4.2312	4.2339
BODY	FE	Spine1	L3L4	2	2.5924	4.8489	0.4883	0.1884	1.8704	2.1840	4.4440	4.4633	4.4537
BODY	FE	Spine1	L3L4	4	2.3366	5.0182	0.5007	0.2143	2.1476	2.5120	4.9907	4.9914	4.9911
BODY	FE	Spine1	L3L4	6	2.3052	3.4546	0.3506	0.1521	1.4986	1.7800	4.9528	5.3486	5.1507
BODY	FE	Spine1	L3L4	8	2.0204	5.2198	0.5323	0.2635	2.5835	2.9680	5.5327	5.5431	5.5379
BODY	FE	Spine1	L3L4	10	2.1725	4.2197	0.4257	0.1960	1.9423	2.2580	5.3068	5.2651	5.2859
BODY	FE	Spine1	L3L4	12	2.2488	4.1737	0.4081	0.1815	1.8560	2.1880	5.4709	5.2523	5.3616
BODY	FE	Spine1	L5S1	0.5	3.2812	9.9082	1.0480	0.3194	3.0197	3.7200	3.2971	3.8294	3.5632
BODY	FE	Spine1	L5S1	1	3.1282	8.8826	0.9934	0.3176	2.8395	3.3900	3.2204	3.5894	3.4049
BODY	FE	Spine1	L5S1	1	3.1510	9.8621	1.0812	0.3431	3.1298	3.6640	4.1944	3.4739	3.8342
BODY	FE	Spine1	L5S1	2	3.0996	9.6013	1.0246	0.3306	3.0976	3.4320	4.1082	3.8265	3.9673
BODY	FE	Spine1	L5S1	4	2.8784	8.3140	0.9362	0.3252	2.8884	3.5580	3.5198	4.1089	3.8144

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	FE	Spine1	L5S1	6	3.0154	8.3250	0.9336	0.3096	2.7608	3.2700	3.4191	3.5242	3.4717
BODY	FE	Spine1	L5S1	8	2.6239	8.4654	0.9124	0.3477	3.2263	3.7800	4.0308	4.1625	4.0966
BODY	FE	Spine1	L5S1	10	2.8139	6.8096	0.7033	0.2499	2.4200	2.9300	4.1918	4.1021	4.1469
BODY	FE	Spine1	L5S1	12	3.1395	7.2178	0.7673	0.2444	2.2990	2.7600	3.6387	3.5249	3.5818
ROOM	FE	Spine2	L1L2	1	4.9183	4.6117	1.2753	0.2593	0.9377	0.9380	0.6978	0.7845	0.7411
ROOM	FE	Spine2	L1L2	2	4.8822	4.7575	1.3342	0.2733	0.9745	0.9760	0.6900	0.7816	0.7358
ROOM	FE	Spine2	L1L2	4	4.7896	5.1521	1.4187	0.2962	1.0757	1.0780	0.7161	0.8047	0.7604
ROOM	FE	Spine2	L1L2	6	4.5518	5.9216	1.6470	0.3618	1.3010	1.3040	0.6935	0.9366	0.8150
ROOM	FE	Spine2	L1L2	6	4.8133	5.4900	1.5081	0.3133	1.1406	1.1420	0.6941	0.8439	0.7690
ROOM	FE	Spine2	L1L2	8	4.8176	5.7632	1.4997	0.3113	1.1963	1.2000	0.7358	0.8835	0.8096
ROOM	FE	Spine2	L1L2	10	4.7627	5.6369	1.5631	0.3282	1.1835	1.1860	0.6857	0.8607	0.7732
ROOM	FE	Spine2	L1L2	10	4.8631	5.6948	1.8785	0.3863	1.1710	1.1740	0.5612	0.6893	0.6253
ROOM	FE	Spine2	L1L2	12	4.6314	5.8305	1.6899	0.3649	1.2589	1.2620	0.6528	0.8825	0.7677
ROOM	FE	Spine2	L1L2	14	4.7272	7.9170	2.0026	0.4236	1.6748	1.6860	0.6992	1.0436	0.8714
ROOM	FE	Spine2	L3L4	0.25	9.4585	17.391	3.6415	0.3850	1.8386	1.8480	0.6577	0.4228	0.5403
ROOM	FE	Spine2	L3L4	0.5	9.3077	16.619	3.4338	0.3689	1.7855	1.7900	0.6280	0.4518	0.5399
ROOM	FE	Spine2	L3L4	0.5	9.3656	17.369	3.5961	0.3840	1.8545	1.8600	0.6151	0.4477	0.5314
ROOM	FE	Spine2	L3L4	1	9.1436	15.475	3.2582	0.3563	1.6924	1.6980	0.6381	0.4509	0.5445
ROOM	FE	Spine2	L3L4	1	9.1473	15.941	3.4318	0.3752	1.7427	1.7520	0.6319	0.4350	0.5335
ROOM	FE	Spine2	L3L4	1	9.2138	17.199	3.6683	0.3981	1.8667	1.8740	0.6122	0.4366	0.5244
ROOM	FE	Spine2	L3L4	2	9.0322	15.702	3.4060	0.3771	1.7384	1.7480	0.6376	0.4359	0.5368
ROOM	FE	Spine2	L3L4	2	9.0909	17.222	3.6283	0.3991	1.8944	1.9020	0.6414	0.4436	0.5425
ROOM	FE	Spine2	L3L4	4	8.9995	16.494	3.4941	0.3883	1.8328	1.8400	0.6425	0.4491	0.5458
ROOM	FE	Spine2	L3L4	4	9.0266	17.491	3.5829	0.3969	1.9377	1.9440	0.6654	0.4603	0.5628
ROOM	FE	Spine2	L3L4	6	8.9150	16.342	3.4297	0.3847	1.8330	1.8420	0.6615	0.4568	0.5591
ROOM	FE	Spine2	L3L4	6	8.9559	17.874	3.5608	0.3976	1.9958	2.0060	0.6838	0.4793	0.5816
ROOM	FE	Spine2	L3L4	8	8.8781	16.876	3.4101	0.3841	1.9009	1.9120	0.6636	0.4854	0.5745
ROOM	FE	Spine2	L3L4	8	8.9476	17.143	3.4398	0.3844	1.9159	1.9240	0.6630	0.4849	0.5739
ROOM	FE	Spine2	L3L4	10	8.8425	17.207	3.5132	0.3973	1.9459	1.9560	0.6751	0.4737	0.5744
ROOM	FE	Spine2	L3L4	10	8.9366	17.652	3.5406	0.3962	1.9753	1.9860	0.6747	0.4795	0.5771
ROOM	FE	Spine2	L3L4	12	8.8998	17.800	3.5504	0.3989	2.0000	2.0100	0.6375	0.5010	0.5693
ROOM	FE	Spine2	L3L4	12	8.9010	17.281	3.2422	0.3642	1.9415	1.9540	0.6515	0.5530	0.6023
ROOM	FE	Spine2	L3L4	14	8.9048	18.295	3.7145	0.4171	2.0545	2.0620	0.6381	0.4829	0.5605

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	FE	Spine2	L5S1	0.25	11.264	28.634	3.5649	0.3165	2.5421	2.8360	0.8765	0.9657	0.9211
BODY	FE	Spine2	L5S1	0.5	10.824	25.877	3.2227	0.2977	2.3907	2.6580	0.9581	1.0608	1.0095
BODY	FE	Spine2	L5S1	0.5	10.932	26.272	3.2269	0.2952	2.4032	2.6760	0.8760	1.0593	0.9676
BODY	FE	Spine2	L5S1	1	10.258	23.446	3.1176	0.3039	2.2856	2.4620	1.0092	1.1390	1.0741
BODY	FE	Spine2	L5S1	1	10.356	23.110	3.0506	0.2946	2.2317	2.4120	0.9128	1.0533	0.9831
BODY	FE	Spine2	L5S1	1	10.652	24.519	3.0473	0.2861	2.3019	2.5360	0.9250	1.0722	0.9986
BODY	FE	Spine2	L5S1	2	10.142	22.265	2.9550	0.2914	2.1954	2.3440	0.9627	1.0979	1.0303
BODY	FE	Spine2	L5S1	2	10.420	22.921	2.8758	0.2760	2.1997	2.3880	0.9381	1.0895	1.0138
BODY	FE	Spine2	L5S1	4	10.146	21.580	2.5842	0.2547	2.1270	2.0700	1.0320	1.1335	1.0828
BODY	FE	Spine2	L5S1	6	9.9453	22.771	2.9503	0.2966	2.2896	2.3660	1.0266	1.1693	1.0980
BODY	FE	Spine2	L5S1	6	9.9783	22.651	2.8280	0.2834	2.2700	2.3200	0.9882	1.1241	1.0561
BODY	FE	Spine2	L5S1	10	9.8662	24.079	2.9828	0.3023	2.4406	2.5580	0.9853	1.1535	1.0694
BODY	FE	Spine2	L5S1	10	9.9093	21.806	2.7801	0.2806	2.2006	2.2760	1.0306	1.2275	1.1290
BODY	FE	Spine2	L5S1	12	9.7951	25.093	3.0408	0.3104	2.5618	2.6560	0.9749	1.2026	1.0888
BODY	FE	Spine2	L5S1	14	9.8679	24.935	3.1551	0.3197	2.5269	2.6540	1.0130	1.1690	1.0910
ROOM	FE	Spine3	L1L2	0.25	9.1642	14.614	2.7145	0.2962	1.5947	1.1060	0.4821	0.3500	0.4161
ROOM	FE	Spine3	L1L2	0.5	8.9191	14.038	2.7481	0.3081	1.5739	1.1280	0.4845	0.3497	0.4171
ROOM	FE	Spine3	L1L2	0.5	9.0125	12.937	2.6481	0.2938	1.4355	1.0420	0.4386	0.3523	0.3954
ROOM	FE	Spine3	L1L2	1	8.6072	12.544	2.3065	0.2680	1.4574	1.0460	0.5123	0.4053	0.4588
ROOM	FE	Spine3	L1L2	1	8.6946	13.289	2.6785	0.3081	1.5284	1.1300	0.4907	0.3631	0.4269
ROOM	FE	Spine3	L1L2	1	8.7528	12.868	2.4698	0.2822	1.4702	1.0200	0.4701	0.3644	0.4173
ROOM	FE	Spine3	L1L2	2	8.4324	12.385	2.2926	0.2719	1.4687	1.0560	0.5102	0.4190	0.4646
ROOM	FE	Spine3	L1L2	2	8.5099	12.978	2.6247	0.3084	1.5251	1.1800	0.5289	0.3811	0.4550
ROOM	FE	Spine3	L1L2	4	8.3349	12.447	2.6144	0.3137	1.4933	1.1940	0.5335	0.3868	0.4602
ROOM	FE	Spine3	L1L2	4	8.3690	12.618	2.3728	0.2835	1.5077	1.1260	0.5204	0.4331	0.4768
ROOM	FE	Spine3	L1L2	6	8.3112	13.244	2.6495	0.3188	1.5935	1.1860	0.4924	0.4116	0.4520
ROOM	FE	Spine3	L1L2	6	8.3149	12.997	2.4690	0.2969	1.5632	1.1560	0.4883	0.4589	0.4736
ROOM	FE	Spine3	L1L2	8	8.2619	13.538	2.6682	0.3230	1.6386	1.2660	0.4966	0.4607	0.4786
ROOM	FE	Spine3	L1L2	8	8.2718	13.662	2.9720	0.3593	1.6517	1.3380	0.5006	0.4062	0.4534
ROOM	FE	Spine3	L1L2	10	8.2505	13.857	2.6930	0.3264	1.6795	1.2860	0.5141	0.4486	0.4813
ROOM	FE	Spine3	L1L2	10	8.2522	14.301	2.9121	0.3529	1.7330	1.3620	0.5127	0.4298	0.4712
ROOM	FE	Spine3	L1L2	12	8.2314	14.457	2.9409	0.3573	1.7563	1.3720	0.5291	0.4146	0.4719
ROOM	FE	Spine3	L1L2	12	8.2551	14.584	2.9479	0.3571	1.7667	1.3780	0.5175	0.4279	0.4727

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine3	L1L2	14	8.2639	15.266	3.1188	0.3774	1.8473	1.4480	0.4979	0.4463	0.4721
BODY	FE	Spine3	L5S1	0.25	18.449	36.547	12.249	0.6639	1.9809	1.9940	0.1464	0.1596	0.1530
BODY	FE	Spine3	L5S1	0.5	17.917	33.081	11.686	0.6522	1.8464	1.8580	0.1319	0.1512	0.1415
BODY	FE	Spine3	L5S1	0.5	18.325	35.225	12.100	0.6603	1.9222	1.9320	0.1331	0.1494	0.1413
BODY	FE	Spine3	L5S1	1	17.436	31.619	11.411	0.6544	1.8134	1.8220	0.1336	0.1542	0.1439
BODY	FE	Spine3	L5S1	1	17.849	31.265	11.866	0.6648	1.7517	1.7400	0.1197	0.1620	0.1408
BODY	FE	Spine3	L5S1	1	18.032	32.670	11.902	0.6601	1.8118	1.8180	0.1295	0.1409	0.1352
BODY	FE	Spine3	L5S1	2	17.853	32.839	11.886	0.6658	1.8394	1.8500	0.1204	0.1484	0.1344
BODY	FE	Spine3	L5S1	4	17.640	31.110	11.641	0.6599	1.7636	1.7460	0.1190	0.1682	0.1436
BODY	FE	Spine3	L5S1	4	17.848	32.865	11.910	0.6673	1.8414	1.8500	0.1283	0.1534	0.1408
BODY	FE	Spine3	L5S1	6	17.647	31.673	11.633	0.6592	1.7948	1.7780	0.1222	0.1648	0.1435
BODY	FE	Spine3	L5S1	6	17.665	33.675	11.914	0.6744	1.9063	1.9060	0.1349	0.1624	0.1487
BODY	FE	Spine3	L5S1	8	17.622	31.904	11.836	0.6716	1.8105	1.7960	0.1332	0.1667	0.1500
BODY	FE	Spine3	L5S1	8	17.626	34.109	12.119	0.6875	1.9351	1.9580	0.1600	0.1662	0.1631
BODY	FE	Spine3	L5S1	10	17.586	34.110	12.033	0.6843	1.9396	1.9480	0.1400	0.1698	0.1549
BODY	FE	Spine3	L5S1	10	17.684	33.241	11.970	0.6769	1.8797	1.8640	0.1315	0.1814	0.1565
BODY	FE	Spine3	L5S1	12	17.509	33.501	12.259	0.7001	1.9133	1.9560	0.1498	0.2069	0.1784
BODY	FE	Spine3	L5S1	12	17.521	35.928	12.508	0.7139	2.0505	2.1520	0.2212	0.2151	0.2181
BODY	FE	Spine3	L5S1	14	17.542	35.489	12.253	0.6985	2.0232	2.0440	0.1507	0.1922	0.1715
BODY	FE	Spine4	L1L2	0.25	11.182	6.1808	2.2220	0.1987	0.5527	0.5520	0.2801	0.2373	0.2587
BODY	FE	Spine4	L1L2	0.5	10.850	8.2871	3.5372	0.3260	0.7638	0.7640	0.2118	0.2159	0.2138
BODY	FE	Spine4	L1L2	0.5	11.070	9.1855	3.8211	0.3452	0.8298	0.8280	0.2069	0.2239	0.2154
BODY	FE	Spine4	L1L2	1	10.651	8.1773	3.2499	0.3051	0.7678	0.7700	0.2188	0.2578	0.2383
BODY	FE	Spine4	L1L2	1	10.809	8.6305	3.5338	0.3269	0.7985	0.7980	0.2055	0.2529	0.2292
BODY	FE	Spine4	L1L2	1	10.880	8.8471	3.7672	0.3462	0.8131	0.8120	0.2005	0.2304	0.2154
BODY	FE	Spine4	L1L2	2	10.643	8.7731	3.4920	0.3281	0.8243	0.8260	0.2214	0.2497	0.2355
BODY	FE	Spine4	L1L2	2	10.727	8.7788	3.4872	0.3251	0.8184	0.8200	0.2170	0.2545	0.2358
BODY	FE	Spine4	L1L2	4	10.477	9.0055	3.4468	0.3290	0.8595	0.8580	0.2287	0.2742	0.2515
BODY	FE	Spine4	L1L2	4	10.603	8.6835	3.4545	0.3258	0.8189	0.8200	0.2176	0.2606	0.2391
BODY	FE	Spine4	L1L2	6	10.437	8.6741	3.1840	0.3051	0.8311	0.8300	0.2445	0.2790	0.2617
BODY	FE	Spine4	L1L2	6	10.475	9.2823	3.3667	0.3214	0.8861	0.8880	0.2398	0.2949	0.2674
BODY	FE	Spine4	L1L2	8	10.428	8.9759	3.3652	0.3227	0.8608	0.8620	0.2341	0.2833	0.2587
BODY	FE	Spine4	L1L2	8	10.440	9.0463	3.3865	0.3244	0.8665	0.8680	0.2341	0.2833	0.2587

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	FE	Spine4	L1L2	10	10.371	9.5141	3.3776	0.3257	0.9174	0.9180	0.2524	0.2921	0.2723
BODY	FE	Spine4	L1L2	10	10.440	9.3859	3.6225	0.3470	0.8991	0.9000	0.2272	0.2714	0.2493
BODY	FE	Spine4	L1L2	12	10.433	9.9057	3.7887	0.3632	0.9495	0.9500	0.2221	0.2885	0.2553
BODY	FE	Spine4	L1L2	12	10.452	9.7948	3.7148	0.3554	0.9371	0.9380	0.2277	0.2816	0.2547
BODY	FE	Spine4	L1L2	14	10.299	10.025	3.8374	0.3726	0.9734	0.9740	0.2278	0.2833	0.2555
ROOM	FE	Spine4	L5S1	0.25	16.957	20.868	11.353	0.6696	1.2307	1.2240	0.1539	0.0935	0.1237
ROOM	FE	Spine4	L5S1	0.5	16.751	25.212	11.368	0.6786	1.5051	1.5240	0.1547	0.1224	0.1385
ROOM	FE	Spine4	L5S1	0.5	16.799	20.441	11.071	0.6590	1.2168	1.2280	0.1402	0.0874	0.1138
ROOM	FE	Spine4	L5S1	1	14.833	18.321	9.5100	0.6412	1.2352	1.2140	0.1848	0.1106	0.1477
ROOM	FE	Spine4	L5S1	1	16.656	20.308	11.133	0.6684	1.2193	1.2240	0.1577	0.1021	0.1299
ROOM	FE	Spine4	L5S1	1	16.749	19.938	11.005	0.6570	1.1904	1.1980	0.1362	0.0865	0.1113
ROOM	FE	Spine4	L5S1	2	16.566	19.470	10.343	0.6244	1.1753	1.2200	0.1338	0.0913	0.1126
ROOM	FE	Spine4	L5S1	4	16.432	21.072	10.917	0.6644	1.2824	1.2920	0.1432	0.0969	0.1200
ROOM	FE	Spine4	L5S1	6	16.380	16.573	9.0895	0.5549	1.0118	1.2180	0.1110	0.1268	0.1189
ROOM	FE	Spine4	L5S1	6	16.441	21.308	10.529	0.6404	1.2961	1.3320	0.1355	0.1063	0.1209
ROOM	FE	Spine4	L5S1	8	16.357	21.237	10.875	0.6648	1.2984	1.3040	0.1544	0.0991	0.1267
ROOM	FE	Spine4	L5S1	8	16.379	24.011	10.526	0.6426	1.4659	1.4560	0.1372	0.1345	0.1358
ROOM	FE	Spine4	L5S1	10	16.360	21.542	10.828	0.6619	1.3168	1.3180	0.1291	0.1216	0.1254
ROOM	FE	Spine4	L5S1	10	16.387	23.624	10.346	0.6314	1.4416	1.4600	0.1779	0.1042	0.1410
ROOM	FE	Spine4	L5S1	12	16.280	23.333	11.279	0.6928	1.4332	1.4460	0.1730	0.1558	0.1644
ROOM	FE	Spine4	L5S1	12	16.418	24.814	10.746	0.6546	1.5114	1.5140	0.1378	0.1221	0.1300
ROOM	FE	Spine4	L5S1	14	16.452	25.138	11.553	0.7023	1.5280	1.5400	0.1494	0.1500	0.1497
BODY	FE	Spine5	L1L2	0.25	4.3976	7.5138	2.0497	0.4661	1.7086	1.2360	1.0139	0.4800	0.7469
BODY	FE	Spine5	L1L2	0.5	4.3736	7.7017	2.0074	0.4590	1.7610	1.2880	1.2003	0.4894	0.8449
BODY	FE	Spine5	L1L2	1	4.1545	7.1279	1.7400	0.4188	1.7157	1.1480	1.2099	0.4597	0.8348
BODY	FE	Spine5	L1L2	1	4.2039	7.5901	1.8006	0.4283	1.8055	1.1980	1.2307	0.4190	0.8248
BODY	FE	Spine5	L1L2	2	4.1986	7.0750	1.5934	0.3795	1.6851	0.9460	0.8866	0.5037	0.6951
BODY	FE	Spine5	L1L2	4	4.0992	5.4412	0.9581	0.2337	1.3274	0.6000	0.7603	0.5721	0.6662
ROOM	FE	Spine5	L3L4	0.5	18.979	15.578	3.3921	0.1787	0.8208	0.8280	0.2395	0.2472	0.2433
ROOM	FE	Spine5	L3L4	1	18.666	12.908	2.9638	0.1588	0.6915	0.6960	0.2293	0.2431	0.2362
ROOM	FE	Spine5	L3L4	1	18.774	16.099	3.5510	0.1891	0.8575	0.8620	0.2414	0.2424	0.2419
ROOM	FE	Spine5	L3L4	2	18.674	12.851	2.8302	0.1516	0.6882	0.6960	0.2398	0.2533	0.2465
ROOM	FE	Spine5	L3L4	4	18.446	19.109	4.3876	0.2379	1.0360	1.0420	0.2255	0.2563	0.2409

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine5	L3L4	6	18.372	14.303	3.2928	0.1792	0.7785	0.7860	0.2304	0.2512	0.2408
ROOM	FE	Spine5	L3L4	8	18.195	31.586	7.1916	0.3952	1.7359	1.7500	0.2200	0.2653	0.2426
ROOM	FE	Spine5	L3L4	10	18.407	13.201	2.9460	0.1601	0.7172	0.7240	0.2387	0.2594	0.2491
ROOM	FE	Spine5	L3L4	12	18.513	4.2748	0.9607	0.0519	0.2309	0.2320	0.2439	0.2512	0.2475
BODY	FE	Spine6	L3L4	0.5	3.9071	8.3514	0.7415	0.1898	2.1375	2.7600	3.7780	3.6556	3.7168
BODY	FE	Spine6	L3L4	1	3.6069	7.7908	0.6966	0.1931	2.1600	2.7600	3.9818	3.9124	3.9471
BODY	FE	Spine6	L3L4	2	3.5061	7.7204	0.6860	0.1957	2.2020	2.8340	4.1228	4.1026	4.1127
BODY	FE	Spine6	L3L4	4	3.0958	7.7032	0.6986	0.2257	2.4883	3.1440	4.5634	4.4101	4.4868
BODY	FE	Spine6	L3L4	6	3.2885	7.3409	0.6413	0.1950	2.2323	2.9420	4.6202	4.5268	4.5735
BODY	FE	Spine6	L3L4	8	2.4097	7.5427	0.7311	0.3034	3.1301	3.6960	5.1696	4.8762	5.0229
BODY	FE	Spine6	L3L4	10	3.1219	6.8603	0.6202	0.1987	2.1974	2.7980	4.6919	4.3695	4.5307
BODY	FE	Spine6	L3L4	12	3.3706	7.4549	0.6492	0.1926	2.2117	2.9240	4.5610	4.4262	4.4936
BODY	FE	Spine7	L1L2	0.25	7.5542	16.979	2.4113	0.3192	2.2476	2.1160	1.1954	0.7176	0.9565
BODY	FE	Spine7	L1L2	0.5	7.1691	14.722	2.2950	0.3201	2.0536	1.8960	1.1094	0.7024	0.9059
BODY	FE	Spine7	L1L2	0.5	7.3561	16.801	2.4459	0.3325	2.2839	2.1580	1.2151	0.6895	0.9523
BODY	FE	Spine7	L1L2	1	6.8601	13.546	2.2163	0.3231	1.9746	1.7740	1.0481	0.6912	0.8697
BODY	FE	Spine7	L1L2	1	7.1143	15.342	2.2761	0.3199	2.1565	1.9840	1.1651	0.7100	0.9375
BODY	FE	Spine7	L1L2	1	7.3280	14.461	2.0666	0.2820	1.9734	1.8520	1.1558	0.7903	0.9731
BODY	FE	Spine7	L1L2	2	6.9494	14.521	2.2211	0.3196	2.0896	1.9060	1.1262	0.7447	0.9354
BODY	FE	Spine7	L1L2	2	7.0086	13.779	2.0153	0.2875	1.9660	1.7620	1.1041	0.8231	0.9636
BODY	FE	Spine7	L1L2	4	6.6281	14.062	2.3702	0.3576	2.1216	2.0080	1.1384	0.7182	0.9283
BODY	FE	Spine7	L1L2	6	6.6106	14.146	2.2724	0.3437	2.1399	1.8980	0.9791	0.8826	0.9308
BODY	FE	Spine7	L1L2	6	6.6457	13.691	2.1970	0.3306	2.0601	1.8280	1.0000	0.8511	0.9256
BODY	FE	Spine7	L1L2	8	6.6619	14.106	2.3523	0.3531	2.1174	1.9700	1.0402	0.7763	0.9083
BODY	FE	Spine7	L1L2	10	6.4400	12.529	1.8837	0.2925	1.9455	1.7500	1.1639	0.7504	0.9572
BODY	FE	Spine7	L1L2	10	6.7170	14.533	2.3126	0.3443	2.1636	2.0400	1.0595	0.8273	0.9434
BODY	FE	Spine7	L1L2	12	6.6517	14.497	2.4215	0.3640	2.1794	2.0660	1.0470	0.7427	0.8949
BODY	FE	Spine7	L1L2	14	6.6065	15.058	2.4906	0.3770	2.2792	2.1900	1.0858	0.8187	0.9522
ROOM	FE	Spine7	L5S1	0.25	8.5619	16.199	2.5767	0.3009	1.8919	2.0040	1.4661	0.8368	1.1514
ROOM	FE	Spine7	L5S1	0.5	8.3107	14.929	2.4646	0.2966	1.7964	1.9120	1.4660	0.9554	1.2107
ROOM	FE	Spine7	L5S1	0.5	8.4651	15.294	2.5204	0.2977	1.8067	1.9080	1.4084	0.8794	1.1439
ROOM	FE	Spine7	L5S1	1	7.9908	13.772	2.3239	0.2908	1.7235	1.8700	1.4482	1.0798	1.2640
ROOM	FE	Spine7	L5S1	1	8.1841	14.602	2.3946	0.2926	1.7842	1.8900	1.4823	0.8763	1.1793

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine7	L5S1	1	8.3947	15.098	2.5084	0.2988	1.7985	1.8920	1.3572	0.8775	1.1173
ROOM	FE	Spine7	L5S1	2	7.8688	13.847	2.3734	0.3016	1.7597	1.8260	1.4267	1.2015	1.3141
ROOM	FE	Spine7	L5S1	2	8.0107	14.234	2.4482	0.3056	1.7768	1.8960	1.5041	0.9386	1.2213
ROOM	FE	Spine7	L5S1	4	7.8347	13.946	2.4158	0.3083	1.7801	1.8700	1.3806	1.1644	1.2725
ROOM	FE	Spine7	L5S1	4	7.9566	14.588	2.4854	0.3124	1.8335	1.9780	1.5398	0.9592	1.2495
ROOM	FE	Spine7	L5S1	6	7.6688	14.379	2.4145	0.3148	1.8750	1.9180	1.5125	1.2161	1.3643
ROOM	FE	Spine7	L5S1	6	7.7548	14.504	2.5204	0.3250	1.8704	1.9960	1.5600	1.0713	1.3157
ROOM	FE	Spine7	L5S1	8	7.2003	13.653	2.1032	0.2921	1.8963	1.9940	1.5390	0.9604	1.2497
ROOM	FE	Spine7	L5S1	8	7.2163	13.576	2.2797	0.3159	1.8813	2.0820	1.5861	0.9629	1.2745
ROOM	FE	Spine7	L5S1	10	7.4775	14.491	2.4322	0.3253	1.9379	2.1740	1.8809	1.0553	1.4681
ROOM	FE	Spine7	L5S1	10	7.8544	14.494	2.3183	0.2952	1.8453	1.9060	1.3214	0.7091	1.0153
ROOM	FE	Spine7	L5S1	12	7.4098	14.612	2.3514	0.3173	1.9720	2.0380	1.5095	0.8075	1.1585
ROOM	FE	Spine7	L5S1	12	7.6967	14.681	2.0218	0.2627	1.9074	1.8380	1.2699	0.7761	1.0230
ROOM	FE	Spine7	L5S1	14	7.3083	15.172	2.1656	0.2963	2.0761	2.0680	1.4231	0.8347	1.1289
ROOM	FE	Spine8	L1L2	0.25	11.519	17.436	4.7972	0.4165	1.5137	1.4080	0.3796	0.2758	0.3277
ROOM	FE	Spine8	L1L2	0.5	11.212	16.508	4.7076	0.4199	1.4723	1.4040	0.3908	0.3107	0.3507
ROOM	FE	Spine8	L1L2	0.5	11.300	16.783	4.7262	0.4182	1.4852	1.4240	0.3828	0.3118	0.3473
ROOM	FE	Spine8	L1L2	1	11.033	16.179	4.5711	0.4143	1.4665	1.4020	0.3921	0.3257	0.3589
ROOM	FE	Spine8	L1L2	1	11.142	16.374	4.2861	0.3847	1.4696	1.4020	0.3909	0.3295	0.3602
ROOM	FE	Spine8	L1L2	1	11.180	16.535	4.6250	0.4137	1.4789	1.4040	0.3908	0.3018	0.3463
ROOM	FE	Spine8	L1L2	2	10.920	15.863	4.0838	0.3740	1.4526	1.3900	0.4169	0.3603	0.3886
ROOM	FE	Spine8	L1L2	2	10.981	16.659	4.6654	0.4249	1.5170	1.4820	0.3947	0.3332	0.3640
ROOM	FE	Spine8	L1L2	4	10.833	16.439	4.8917	0.4516	1.5176	1.5300	0.4156	0.3215	0.3685
ROOM	FE	Spine8	L1L2	6	10.725	17.540	4.4336	0.4134	1.6354	1.6140	0.4700	0.3685	0.4193
ROOM	FE	Spine8	L1L2	6	10.777	17.407	4.4999	0.4175	1.6152	1.5800	0.4038	0.3688	0.3863
ROOM	FE	Spine8	L1L2	8	10.713	18.311	4.9388	0.4610	1.7093	1.6340	0.4468	0.3313	0.3891
ROOM	FE	Spine8	L1L2	10	10.677	19.766	4.6707	0.4374	1.8512	1.7640	0.5278	0.3749	0.4514
ROOM	FE	Spine8	L1L2	10	10.780	19.199	4.9586	0.4600	1.7811	1.7140	0.5034	0.3575	0.4305
ROOM	FE	Spine8	L1L2	12	10.679	20.732	5.1094	0.4784	1.9413	1.9160	0.5203	0.4218	0.4710
ROOM	FE	Spine8	L1L2	14	10.547	21.269	4.8089	0.4560	2.0166	1.9440	0.5114	0.4134	0.4624
ROOM	FE	Spine8	L3L4	0.25	11.770	12.956	2.6393	0.2242	1.1008	1.1020	0.4602	0.3955	0.4279
ROOM	FE	Spine8	L3L4	0.5	11.552	12.178	2.5151	0.2177	1.0542	1.0560	0.4509	0.4016	0.4263
ROOM	FE	Spine8	L3L4	0.5	11.575	12.482	2.6050	0.2250	1.0783	1.0840	0.4511	0.3937	0.4224

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine8	L3L4	1	11.404	12.394	2.5327	0.2221	1.0868	1.0940	0.4506	0.4159	0.4332
ROOM	FE	Spine8	L3L4	1	11.411	12.125	2.5148	0.2204	1.0626	1.0640	0.4510	0.4059	0.4284
ROOM	FE	Spine8	L3L4	1	11.513	11.985	2.4233	0.2105	1.0410	1.0440	0.4571	0.4141	0.4356
ROOM	FE	Spine8	L3L4	2	11.347	12.238	2.4794	0.2185	1.0785	1.0840	0.4572	0.4218	0.4395
ROOM	FE	Spine8	L3L4	2	11.433	12.024	2.4439	0.2138	1.0517	1.0580	0.4550	0.4158	0.4354
ROOM	FE	Spine8	L3L4	4	11.249	12.736	2.6058	0.2316	1.1322	1.1380	0.4607	0.4180	0.4394
ROOM	FE	Spine8	L3L4	6	11.170	12.921	2.6177	0.2343	1.1568	1.1640	0.4649	0.4270	0.4460
ROOM	FE	Spine8	L3L4	6	11.282	13.085	2.6135	0.2317	1.1599	1.1680	0.4617	0.4322	0.4470
ROOM	FE	Spine8	L3L4	8	11.164	13.606	2.7667	0.2478	1.2187	1.2260	0.4639	0.4243	0.4441
ROOM	FE	Spine8	L3L4	10	11.131	14.208	2.8770	0.2585	1.2765	1.2860	0.4648	0.4280	0.4464
ROOM	FE	Spine8	L3L4	10	11.206	14.366	2.9053	0.2593	1.2820	1.2880	0.4698	0.4214	0.4456
ROOM	FE	Spine8	L3L4	12	11.115	14.436	2.9131	0.2621	1.2988	1.3080	0.4635	0.4327	0.4481
ROOM	FE	Spine8	L3L4	14	11.102	15.227	3.1094	0.2801	1.3715	1.3800	0.4578	0.4270	0.4424
BODY	FE	Spine8	L5S1	0.25	4.2828	8.4473	0.7990	0.1866	1.9724	2.4000	2.9405	3.0685	3.0045
BODY	FE	Spine8	L5S1	0.5	3.9851	7.6906	0.7284	0.1828	1.9298	2.3440	3.1643	3.2558	3.2100
BODY	FE	Spine8	L5S1	0.5	4.1175	8.1074	0.7714	0.1873	1.9690	2.3880	3.0271	3.1644	3.0957
BODY	FE	Spine8	L5S1	1	3.3524	6.2177	0.6056	0.1806	1.8547	2.1980	3.5620	3.6908	3.6264
BODY	FE	Spine8	L5S1	1	3.6293	6.9821	0.6715	0.1850	1.9238	2.3000	3.3848	3.4531	3.4190
BODY	FE	Spine8	L5S1	1	3.8564	7.1500	0.6828	0.1770	1.8541	2.2340	3.2055	3.3366	3.2710
BODY	FE	Spine8	L5S1	2	3.1938	5.8409	0.5722	0.1792	1.8288	2.1560	3.6935	3.8370	3.7653
BODY	FE	Spine8	L5S1	2	3.6167	6.7715	0.6582	0.1820	1.8723	2.2240	3.3085	3.4506	3.3795
BODY	FE	Spine8	L5S1	4	2.9315	5.6697	0.5727	0.1954	1.9340	2.2320	3.8399	3.9336	3.8867
BODY	FE	Spine8	L5S1	4	3.4337	6.7215	0.6509	0.1896	1.9575	2.3320	3.5147	3.6374	3.5761
BODY	FE	Spine8	L5S1	6	2.8846	5.7492	0.5819	0.2017	1.9930	2.2960	3.9248	3.9408	3.9328
BODY	FE	Spine8	L5S1	6	3.1977	6.6343	0.6513	0.2037	2.0747	2.4400	3.6708	3.8168	3.7438
BODY	FE	Spine8	L5S1	8	2.8686	6.0528	0.6008	0.2094	2.1100	2.4600	4.0092	4.1660	4.0876
BODY	FE	Spine8	L5S1	8	3.0958	6.4454	0.6285	0.2030	2.0820	2.4580	3.8690	3.9287	3.8988
BODY	FE	Spine8	L5S1	10	2.8100	6.3541	0.6351	0.2260	2.2613	2.6260	4.0375	4.2125	4.1250
BODY	FE	Spine8	L5S1	10	2.9386	6.1979	0.6251	0.2127	2.1091	2.4340	3.8280	3.9362	3.8821
BODY	FE	Spine8	L5S1	12	2.8385	6.2441	0.6199	0.2184	2.1998	2.5680	4.0449	4.2232	4.1341
BODY	FE	Spine8	L5S1	12	2.9381	6.3396	0.6272	0.2135	2.1577	2.5240	3.9717	4.0398	4.0057
BODY	FE	Spine8	L5S1	14	2.8834	6.3893	0.6358	0.2205	2.2158	2.5800	3.9710	4.1291	4.0500

C.3.3. Rate-Targeted Effect DIP-Boltzmann Parameters

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine2	L5S1	0.25	0.5730	-.5131	1.6450	-1.864	1.2101	-.1543	0.6740	-5.278	1.0808
BODY	FE	Spine3	L5S1	0.25	0.8413	0.6910	0.8717	0.7838	0.8868	1.4598	1.1386	1.4188	1.0381
BODY	FE	Spine4	L1L2	0.25	0.7036	1.2256	0.7036	1.2256	0.9839	1.0031	0.9839	1.0031	1.0373
BODY	FE	Spine5	L1L2	0.25	1.1520	1.0522	0.8654	0.8997	0.9804	0.6469	0.8897	0.7628	1.0523
BODY	FE	Spine7	L1L2	0.25	1.1596	1.7671	0.6263	-1.757	1.2104	1.2557	0.5946	0.6955	1.0638
BODY	FE	Spine8	L5S1	0.25	0.9687	0.9486	0.9687	0.9486	0.9583	1.1814	0.9583	1.1814	1.1855
BODY	FE	Spine1	L3L4	0.5	1.0403	2.5934	1.0403	2.5934	1.0203	0.7272	1.0203	0.7272	1.1398
BODY	FE	Spine1	L5S1	0.5	0.6107	-.0136	0.8188	0.0174	1.1354	0.9512	0.7073	0.9454	1.0451
BODY	FE	Spine2	L5S1	0.5	0.5809	-.5864	1.6518	-1.877	1.2687	-.1902	0.6712	-5.326	1.0386
BODY	FE	Spine2	L5S1	0.5	0.9609	0.9854	0.9811	0.9384	1.0682	1.0341	0.9300	0.9407	1.0489
BODY	FE	Spine3	L5S1	0.5	0.9150	0.5616	0.9264	0.6473	0.9228	1.3490	0.9712	1.4786	1.0081
BODY	FE	Spine3	L5S1	0.5	0.8821	0.8038	0.9225	0.8251	8.1492	1.2558	0.1249	1.3611	1.0311
BODY	FE	Spine4	L1L2	0.5	0.9760	1.0469	0.9760	1.0469	1.1343	1.0116	1.1343	1.0116	1.0065
BODY	FE	Spine4	L1L2	0.5	0.9825	0.9714	0.9825	0.9714	1.0759	1.0028	1.0759	1.0028	1.0269
BODY	FE	Spine5	L1L2	0.5	1.1393	1.0682	0.9028	0.9771	9.2182	2.9591	0.0827	0.3961	1.0465
BODY	FE	Spine6	L3L4	0.5	0.9727	1.0999	0.9727	1.0999	0.9877	0.9066	0.9877	0.9066	1.0832
BODY	FE	Spine7	L1L2	0.5	0.4021	-.3800	1.9989	4.7800	1.3105	1.2544	0.5855	0.7457	1.0096
BODY	FE	Spine7	L1L2	0.5	0.4144	-.6004	1.8091	4.6975	1.2609	1.2443	0.5835	0.7746	1.0360
BODY	FE	Spine8	L5S1	0.5	0.9671	0.9012	0.9671	0.9012	0.9703	1.1747	0.9703	1.1747	1.1031
BODY	FE	Spine8	L5S1	0.5	0.9788	0.8976	0.9788	0.8976	0.9666	1.2171	0.9666	1.2171	1.1397
BODY	FE	Spine1	L3L4	1	0.9459	0.4278	0.9459	0.4278	0.9842	0.9956	0.9842	0.9956	0.9943
BODY	FE	Spine1	L3L4	1	1.0541	1.5722	1.0541	1.5722	1.0158	1.0044	1.0158	1.0044	1.0057
BODY	FE	Spine1	L5S1	1	0.6556	0.2571	0.8790	-.3299	1.2700	0.9826	0.7913	0.9767	0.9964
BODY	FE	Spine1	L5S1	1	1.3444	1.7429	1.1210	2.3299	0.7300	1.0174	1.2087	1.0233	1.0036
BODY	FE	Spine2	L5S1	1	1.0407	1.0480	0.9873	1.0391	0.9434	1.0110	1.0448	1.0928	0.9843
BODY	FE	Spine2	L5S1	1	0.9936	0.9606	1.0001	0.9529	1.0170	0.9733	1.0187	0.9364	0.9937
BODY	FE	Spine2	L5S1	1	0.9657	0.9913	1.0126	1.0080	1.0396	1.0157	0.9365	0.9708	1.0221
BODY	FE	Spine3	L5S1	1	0.9105	0.4444	0.9726	0.5644	0.9292	1.3819	1.0387	1.5518	0.9811
BODY	FE	Spine3	L5S1	1	1.0947	1.7333	1.0570	1.5818	1.0788	0.5112	0.8022	0.2240	1.0043
BODY	FE	Spine3	L5S1	1	0.9948	0.8223	0.9704	0.8538	0.9919	1.1069	1.1591	1.2242	1.0146
BODY	FE	Spine4	L1L2	1	0.9587	1.0771	0.9587	1.0771	0.9640	1.0312	0.9640	1.0312	0.9880
BODY	FE	Spine4	L1L2	1	1.0098	0.9337	1.0098	0.9337	0.9721	0.9644	0.9721	0.9644	1.0027
BODY	FE	Spine4	L1L2	1	1.0315	0.9893	1.0315	0.9893	1.0638	1.0044	1.0638	1.0044	1.0093

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine5	L1L2	1	1.0722	0.9933	0.9784	0.9948	1.0040	1.4936	0.9199	0.9524	0.9941
BODY	FE	Spine5	L1L2	1	0.9278	1.0067	1.0216	1.0052	0.9960	0.5064	1.0801	1.0476	1.0059
BODY	FE	Spine6	L3L4	1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
BODY	FE	Spine7	L1L2	1	1.3814	1.8271	0.6092	-.3934	1.3748	1.2648	0.6134	0.8147	0.9661
BODY	FE	Spine7	L1L2	1	1.2157	1.7794	0.6135	-1.229	1.2634	1.2461	0.5951	0.7650	1.0019
BODY	FE	Spine7	L1L2	1	0.4029	-.6065	1.7773	4.6220	0.3618	0.4892	1.7915	1.4203	1.0320
BODY	FE	Spine8	L5S1	1	1.0210	1.0424	1.0210	1.0424	1.0173	0.9212	1.0173	0.9212	0.9279
BODY	FE	Spine8	L5S1	1	0.9929	0.9277	0.9929	0.9277	1.0048	1.1159	1.0048	1.1159	1.0046
BODY	FE	Spine8	L5S1	1	0.9860	1.0299	0.9860	1.0299	0.9779	0.9629	0.9779	0.9629	1.0675
BODY	FE	Spine1	L3L4	2	1.0602	1.5969	1.0602	1.5969	1.0160	1.0320	1.0160	1.0320	0.9537
BODY	FE	Spine1	L5S1	2	1.3267	1.8156	1.0581	2.1142	1.3088	1.0376	0.6871	1.0248	0.9873
BODY	FE	Spine2	L5S1	2	1.0020	0.9845	1.0439	0.9931	1.4967	-.1969	0.7305	-4.952	0.9731
BODY	FE	Spine2	L5S1	2	0.6050	-.5608	1.6032	-1.757	1.0139	0.9883	0.9626	1.0659	0.9998
BODY	FE	Spine3	L5S1	2	1.1835	0.9059	1.0442	0.8497	7.4141	1.1410	0.1384	1.1765	1.0045
BODY	FE	Spine4	L1L2	2	0.9518	0.9361	0.9518	0.9361	1.0002	0.9795	1.0002	0.9795	0.9873
BODY	FE	Spine4	L1L2	2	0.9632	0.9816	0.9632	0.9816	0.9729	1.0027	0.9729	1.0027	0.9951
BODY	FE	Spine5	L1L2	2	1.1928	0.9659	0.8657	0.9461	0.9786	0.2273	0.8039	1.0033	1.0046
BODY	FE	Spine6	L3L4	2	0.9939	1.1393	0.9939	1.1393	0.9813	0.9197	0.9813	0.9197	0.9720
BODY	FE	Spine7	L1L2	2	1.2829	1.7674	0.6023	-.9969	0.3617	0.6557	1.9550	1.4526	0.9787
BODY	FE	Spine7	L1L2	2	0.4022	-.4056	1.9103	4.6400	1.1050	1.2530	0.6329	0.6295	0.9870
BODY	FE	Spine8	L5S1	2	1.0335	1.1935	1.0335	1.1935	1.0270	0.7456	1.0270	0.7456	0.8840
BODY	FE	Spine8	L5S1	2	1.0191	1.0222	1.0191	1.0222	1.0088	0.9624	1.0088	0.9624	1.0011
BODY	FE	Spine1	L3L4	4	1.0501	3.0598	1.0501	3.0598	1.0106	1.0496	1.0106	1.0496	0.8596
BODY	FE	Spine1	L5S1	4	0.6529	0.3245	0.8750	-.4146	1.2072	1.0542	0.7524	1.0480	0.9168
BODY	FE	Spine2	L5S1	4	0.7357	-.6249	1.5182	-1.779	1.0044	0.9935	1.0135	1.0392	0.9735
BODY	FE	Spine3	L5S1	4	0.1152	1.6880	8.7639	1.4727	5.4219	0.2514	0.1505	0.6751	0.9925
BODY	FE	Spine3	L5S1	4	0.1125	1.1383	11.394	0.8731	6.7707	0.9957	0.1376	1.1154	1.0042
BODY	FE	Spine4	L1L2	4	0.9363	0.9569	0.9363	0.9569	0.9255	1.0103	0.9255	1.0103	0.9719
BODY	FE	Spine4	L1L2	4	0.9719	0.9399	0.9719	0.9399	0.9615	0.9789	0.9615	0.9789	0.9836
BODY	FE	Spine5	L1L2	4	1.0588	0.8485	0.8851	0.9685	1.0423	3.4138	0.6130	1.1520	0.9809
BODY	FE	Spine6	L3L4	4	1.0201	1.4116	1.0201	1.4116	1.0372	0.8828	1.0372	0.8828	0.8583
BODY	FE	Spine7	L1L2	4	1.3146	1.7292	0.5976	-.6160	1.5091	1.2746	0.6195	0.7951	0.9334
BODY	FE	Spine8	L5S1	4	1.0846	1.3530	1.0846	1.3530	1.0931	0.6646	1.0931	0.6646	0.8115

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine8	L5S1	4	1.0112	1.0189	1.0112	1.0189	1.0087	1.0568	1.0087	1.0568	0.9504
BODY	FE	Spine1	L3L4	6	1.0665	1.5299	1.0665	1.5299	0.9506	0.8171	0.9506	0.8171	0.8480
BODY	FE	Spine1	L5S1	6	0.6397	0.4995	0.8577	-.6408	1.3403	1.0554	0.8350	1.0489	0.9604
BODY	FE	Spine2	L5S1	6	1.0052	1.0333	1.1334	1.0031	1.0444	0.9929	1.0958	1.0325	0.9543
BODY	FE	Spine2	L5S1	6	0.8947	1.0280	1.0878	0.9244	1.0449	0.9622	1.0435	1.0634	0.9574
BODY	FE	Spine3	L5S1	6	0.9339	1.6859	1.0267	1.5113	5.2318	0.3199	0.1483	0.6344	0.9930
BODY	FE	Spine3	L5S1	6	0.7900	1.1537	1.0570	1.1328	1.0299	1.0271	0.8579	0.9513	0.9940
BODY	FE	Spine4	L1L2	6	0.8757	1.0459	0.8757	1.0459	0.9090	1.0468	0.9090	1.0468	0.9682
BODY	FE	Spine4	L1L2	6	0.8921	0.9778	0.8921	0.9778	0.8592	1.0366	0.8592	1.0366	0.9717
BODY	FE	Spine6	L3L4	6	0.9455	1.3146	0.9455	1.3146	0.9481	0.8309	0.9481	0.8309	0.9117
BODY	FE	Spine7	L1L2	6	1.4188	1.5861	0.5677	-.2156	0.4167	0.6591	1.6482	1.5114	0.9310
BODY	FE	Spine7	L1L2	6	0.3753	-.1425	2.1562	4.3109	1.0766	1.2696	0.6345	0.7458	0.9359
BODY	FE	Spine8	L5S1	6	1.0791	1.1006	1.0791	1.1006	1.1095	0.9528	1.1095	0.9528	0.7985
BODY	FE	Spine8	L5S1	6	1.0410	1.1594	1.0410	1.1594	1.0336	1.0230	1.0336	1.0230	0.8851
BODY	FE	Spine1	L3L4	8	1.1022	4.9074	1.1022	4.9074	1.0588	1.0960	1.0588	1.0960	0.7433
BODY	FE	Spine1	L5S1	8	0.6279	0.0509	0.8418	-.0654	1.3130	0.9939	0.8180	0.9878	0.8357
BODY	FE	Spine3	L5S1	8	0.9259	1.5778	1.0552	1.5295	4.8502	0.3396	0.1640	0.7193	0.9915
BODY	FE	Spine3	L5S1	8	1.0945	1.2519	1.0491	1.3038	6.5329	0.7912	0.1444	1.0126	0.9918
BODY	FE	Spine4	L1L2	8	0.9180	1.0070	0.9180	1.0070	0.8986	1.0400	0.8986	1.0400	0.9673
BODY	FE	Spine4	L1L2	8	0.9170	0.9973	0.9170	0.9973	0.8980	1.0375	0.8981	1.0374	0.9685
BODY	FE	Spine6	L3L4	8	1.1693	1.0418	1.1693	1.0418	1.2180	1.6238	1.2180	1.6238	0.6681
BODY	FE	Spine7	L1L2	8	1.3596	1.6816	0.5862	-.2589	1.2140	1.2794	0.5844	0.8459	0.9382
BODY	FE	Spine8	L5S1	8	1.0631	1.3486	1.0631	1.3486	1.0562	0.8648	1.0562	0.8648	0.7940
BODY	FE	Spine8	L5S1	8	1.0201	1.3435	1.0201	1.3435	1.0371	0.8679	1.0371	0.8679	0.8569
BODY	FE	Spine1	L3L4	10	1.0602	1.5727	1.0602	1.5727	1.0286	1.0771	1.0286	1.0771	0.7992
BODY	FE	Spine1	L5S1	10	0.5543	0.5540	0.7432	-.7108	1.2232	0.9922	0.7620	0.9862	0.8963
BODY	FE	Spine2	L5S1	10	0.6408	-.4980	1.5186	-1.832	1.1055	1.0013	1.0383	0.9165	0.9467
BODY	FE	Spine2	L5S1	10	0.5938	-.6175	1.3862	-1.749	1.1200	1.0135	1.1242	0.9974	0.9508
BODY	FE	Spine3	L5S1	10	0.9717	1.3711	1.0489	1.3047	1.0599	0.9393	0.8543	0.7605	0.9895
BODY	FE	Spine3	L5S1	10	0.1169	1.6923	7.7261	1.3738	1.1482	0.8478	0.6904	0.3817	0.9950
BODY	FE	Spine4	L1L2	10	0.8566	0.9950	0.8566	0.9950	0.8769	1.0632	0.8769	1.0632	0.9620
BODY	FE	Spine4	L1L2	10	0.9491	0.9816	0.9491	0.9816	0.9413	1.0455	0.9413	1.0455	0.9684
BODY	FE	Spine6	L3L4	10	0.9811	1.0808	0.9811	1.0808	1.0351	0.9516	1.0351	0.9516	0.8655

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
BODY	FE	Spine7	L1L2	10	1.1673	1.7785	0.6846	-.4788	1.1587	1.1781	0.6209	0.8504	0.9069
BODY	FE	Spine7	L1L2	10	1.2339	1.6039	0.5564	-.3973	1.1284	1.2902	0.5954	0.7851	0.9459
BODY	FE	Spine8	L5S1	10	1.0797	1.2940	1.0797	1.2940	1.0683	1.0567	1.0683	1.0567	0.7778
BODY	FE	Spine8	L5S1	10	1.0873	1.3333	1.0873	1.3333	1.0917	0.8563	1.0917	0.8563	0.8134
BODY	FE	Spine1	L3L4	12	0.9922	3.4886	0.9922	3.4886	0.9947	0.8227	0.9947	0.8227	0.8273
BODY	FE	Spine1	L5S1	12	0.5719	0.7471	0.7668	-.9586	1.2749	1.0311	0.7943	1.0248	1.0000
BODY	FE	Spine2	L5S1	12	0.6171	-.4589	1.4318	-1.830	1.5255	-.1741	0.7825	-5.272	0.9399
BODY	FE	Spine3	L5S1	12	1.0242	1.5854	1.0910	1.4929	1.1172	0.8586	1.0076	0.4172	0.9852
BODY	FE	Spine3	L5S1	12	0.1142	1.8037	10.596	1.2318	6.3819	0.5538	0.1499	1.1182	0.9859
BODY	FE	Spine4	L1L2	12	0.9746	0.9655	0.9746	0.9655	0.8887	1.0631	0.8887	1.0631	0.9678
BODY	FE	Spine4	L1L2	12	0.9473	0.9367	0.9473	0.9367	0.9075	1.0398	0.9075	1.0398	0.9696
BODY	FE	Spine6	L3L4	12	0.9342	1.1841	0.9342	1.1841	0.9459	0.9417	0.9459	0.9417	0.9345
BODY	FE	Spine7	L1L2	12	0.3623	-.1079	1.9719	4.1713	1.2415	1.2313	0.5396	0.8974	0.9368
BODY	FE	Spine8	L5S1	12	1.0660	1.2456	1.0660	1.2456	1.0540	1.0512	1.0540	1.0512	0.7857
BODY	FE	Spine8	L5S1	12	1.0482	1.2929	1.0482	1.2929	1.0640	0.9684	1.0640	0.9684	0.8133
BODY	FE	Spine2	L5S1	14	0.9250	1.0625	1.0628	0.9049	1.1115	1.0167	1.0791	0.8833	0.9469
BODY	FE	Spine3	L5S1	14	0.7883	1.5617	1.0519	1.4846	6.2323	0.5385	0.1508	1.0305	0.9870
BODY	FE	Spine4	L1L2	14	0.9645	0.9461	0.9645	0.9461	0.9189	1.0645	0.9189	1.0645	0.9553
BODY	FE	Spine7	L1L2	14	1.2733	1.5702	0.6049	-.4291	0.3913	0.7034	1.9186	1.5072	0.9304
BODY	FE	Spine8	L5S1	14	1.0691	1.2594	1.0691	1.2594	1.0615	1.0502	1.0615	1.0502	0.7981
ROOM	FE	Spine1	L1L2	0.25	0.1973	75.979	4.7649	-.0068	0.9734	1.0047	0.9162	1.0460	1.0156
ROOM	FE	Spine2	L3L4	0.25	0.9260	1.0096	0.9260	1.0096	1.0122	1.0531	1.0122	1.0531	1.0317
ROOM	FE	Spine3	L1L2	0.25	0.4708	24.109	1.2898	2.0189	0.2510	1.1892	2.3862	0.8809	1.0552
ROOM	FE	Spine4	L5S1	0.25	0.2654	2.4169	2.7878	-.5299	0.3863	1.0083	1.3663	0.9598	1.0546
ROOM	FE	Spine7	L5S1	0.25	0.3890	-.1909	1.9628	3.6725	2.0071	1.7884	0.2829	0.4745	1.0454
ROOM	FE	Spine8	L1L2	0.25	0.1925	-7.948	5.0752	-.1337	0.2394	0.3125	2.4203	2.3938	1.0360
ROOM	FE	Spine8	L3L4	0.25	0.9573	1.0458	0.9573	1.0458	1.0132	1.0398	1.0132	1.0398	1.0286
ROOM	FE	Spine1	L1L2	0.5	0.9768	1.5034	0.9900	1.0446	0.9838	0.9884	0.9224	1.0466	1.0054
ROOM	FE	Spine1	L1L2	0.5	0.9916	-.9829	0.9933	1.0693	0.9649	0.9978	0.9581	1.0895	1.0071
ROOM	FE	Spine2	L3L4	0.5	0.9822	0.8064	0.9822	0.8064	0.9591	1.0852	0.9591	1.0852	1.0152
ROOM	FE	Spine2	L3L4	0.5	0.9998	1.0990	0.9998	1.0990	0.9652	1.0317	0.9651	1.0317	1.0215
ROOM	FE	Spine3	L1L2	0.5	0.4793	21.904	1.3225	1.9801	0.2606	1.1508	2.4573	0.8990	1.0270
ROOM	FE	Spine3	L1L2	0.5	0.4817	10.664	1.4126	2.0263	1.3772	0.9539	0.4479	1.1095	1.0377

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine4	L5S1	0.5	1.6951	-.8811	0.3813	2.0669	3.8770	1.0917	0.1705	1.3176	1.0418
ROOM	FE	Spine4	L5S1	0.5	0.2766	2.9963	1.9664	-.2071	2.2030	0.8962	0.2164	1.1501	1.0448
ROOM	FE	Spine5	L3L4	0.5	0.9689	1.0231	0.9689	1.0231	0.9689	1.0400	0.9689	1.0400	1.0139
ROOM	FE	Spine7	L5S1	0.5	0.3949	-.1648	1.9524	3.6661	2.0634	1.7925	0.2937	0.4367	1.0148
ROOM	FE	Spine7	L5S1	0.5	1.3007	1.5712	0.5805	-.3532	0.4377	0.6436	1.3175	1.2699	1.0336
ROOM	FE	Spine8	L1L2	0.5	1.0765	1.2838	0.9698	0.9828	1.4955	1.5529	0.4050	0.2486	1.0085
ROOM	FE	Spine8	L1L2	0.5	1.0389	0.9621	0.9850	0.9878	1.4406	1.5064	0.4055	0.2253	1.0164
ROOM	FE	Spine8	L3L4	0.5	0.9948	1.0620	0.9948	1.0620	1.0161	1.0303	1.0161	1.0303	1.0095
ROOM	FE	Spine8	L3L4	0.5	0.9932	1.0357	0.9932	1.0357	1.0350	1.0250	1.0350	1.0250	1.0116
ROOM	FE	Spine1	L1L2	1	0.9803	4.6128	0.9972	1.0143	0.9945	0.9854	0.8705	1.0923	0.9948
ROOM	FE	Spine1	L1L2	1	1.0369	-1.196	1.0148	0.9312	1.0128	0.9946	1.2089	0.8734	1.0024
ROOM	FE	Spine1	L1L2	1	0.9828	-.4170	0.9880	1.0546	0.9927	1.0200	0.9206	1.0343	1.0027
ROOM	FE	Spine2	L1L2	1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
ROOM	FE	Spine2	L3L4	1	0.9814	0.5297	0.9814	0.5297	0.9758	1.1138	0.9759	1.1138	0.9973
ROOM	FE	Spine2	L3L4	1	0.9945	1.3950	0.9945	1.3950	1.0150	0.8374	1.0150	0.8374	0.9977
ROOM	FE	Spine2	L3L4	1	1.0241	1.0753	1.0241	1.0753	1.0092	1.0488	1.0091	1.0488	1.0050
ROOM	FE	Spine3	L1L2	1	2.0201	-32.28	0.3040	-1.203	0.2677	1.0690	2.0753	0.8473	0.9911
ROOM	FE	Spine3	L1L2	1	0.4891	17.825	1.3091	1.8994	1.3839	0.9431	0.4650	1.0722	1.0011
ROOM	FE	Spine3	L1L2	1	0.4908	17.451	1.3869	2.3039	1.3485	0.9879	0.4597	1.0805	1.0078
ROOM	FE	Spine4	L5S1	1	1.0124	0.6842	0.2752	0.3766	0.4314	1.0376	1.3765	0.8906	0.9225
ROOM	FE	Spine4	L5S1	1	1.7114	-1.205	0.3926	2.2740	0.3968	1.0261	1.4127	0.9362	1.0359
ROOM	FE	Spine4	L5S1	1	0.2762	3.5209	2.3323	0.3493	2.1717	0.9363	0.2108	1.1733	1.0417
ROOM	FE	Spine5	L3L4	1	1.0274	1.0160	1.0274	1.0160	1.0000	0.9615	1.0000	0.9615	0.9971
ROOM	FE	Spine5	L3L4	1	0.9726	0.9840	0.9726	0.9840	1.0000	1.0385	1.0000	1.0385	1.0029
ROOM	FE	Spine7	L5S1	1	0.4058	-.1477	1.8255	3.6186	0.4688	0.5653	1.3591	1.2645	0.9757
ROOM	FE	Spine7	L5S1	1	1.3276	1.5841	0.6032	-.3240	2.0895	1.7806	0.2919	0.4673	0.9993
ROOM	FE	Spine7	L5S1	1	1.2666	1.5636	0.5713	-.2946	0.4417	0.6541	1.3490	1.2683	1.0250
ROOM	FE	Spine8	L1L2	1	1.0631	1.5139	0.9844	0.9424	0.2603	0.1866	2.1922	2.7193	0.9923
ROOM	FE	Spine8	L1L2	1	0.9080	0.5830	1.0103	1.0392	1.2570	1.3856	0.4040	0.0646	1.0021
ROOM	FE	Spine8	L1L2	1	1.0289	0.9032	1.0053	1.0184	1.4827	1.4278	0.4038	0.2161	1.0056
ROOM	FE	Spine8	L3L4	1	1.0088	1.0382	1.0088	1.0382	0.9943	1.0316	0.9943	1.0316	0.9966
ROOM	FE	Spine8	L3L4	1	1.0073	1.0764	1.0073	1.0764	1.0179	1.0421	1.0179	1.0421	0.9972
ROOM	FE	Spine8	L3L4	1	0.9839	0.8854	0.9839	0.8854	0.9879	0.9263	0.9879	0.9263	1.0062

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine1	L1L2	2	0.9647	0.7815	1.0041	1.0019	1.0201	1.0302	0.9576	0.9734	0.9948
ROOM	FE	Spine1	L1L2	2	0.9902	-2.169	1.0280	0.9323	4.4664	0.2386	0.2282	3.3911	0.9968
ROOM	FE	Spine2	L1L2	2	1.0208	0.9929	1.0208	0.9929	1.0133	1.0188	1.0133	1.0188	0.9927
ROOM	FE	Spine2	L3L4	2	0.9984	1.3504	0.9984	1.3504	1.0262	0.8502	1.0261	0.8502	0.9852
ROOM	FE	Spine2	L3L4	2	0.9909	1.2041	0.9909	1.2041	1.0067	1.0240	1.0067	1.0240	0.9916
ROOM	FE	Spine3	L1L2	2	2.0688	-33.00	0.3107	-1.032	1.1723	0.9078	0.4793	1.0590	0.9709
ROOM	FE	Spine3	L1L2	2	0.5040	16.940	1.2055	1.9190	0.2654	1.1098	2.3206	0.9263	0.9798
ROOM	FE	Spine4	L5S1	2	0.2921	2.8129	2.3120	-.9835	0.3376	0.8874	0.9148	0.9891	1.0303
ROOM	FE	Spine5	L3L4	2	0.9813	1.0733	0.9813	1.0733	0.9590	0.9921	0.9590	0.9921	0.9975
ROOM	FE	Spine7	L5S1	2	1.2346	1.5259	0.6293	-.2626	2.1495	1.7907	0.3351	0.4102	0.9608
ROOM	FE	Spine7	L5S1	2	0.4144	-.1093	2.0818	3.6491	0.4651	0.6628	1.4273	1.2564	0.9781
ROOM	FE	Spine8	L1L2	2	0.2076	-8.527	4.4174	-.1497	0.2691	-.0745	1.8539	2.5826	0.9821
ROOM	FE	Spine8	L1L2	2	0.2035	-7.834	4.9602	-.0865	0.2595	0.1228	2.1522	2.5584	0.9876
ROOM	FE	Spine8	L3L4	2	0.9989	1.0292	0.9989	1.0292	0.9849	1.0232	0.9849	1.0232	0.9916
ROOM	FE	Spine8	L3L4	2	0.9958	0.9001	0.9958	0.9001	0.9912	0.9392	0.9912	0.9392	0.9991
ROOM	FE	Spine1	L1L2	4	0.9026	-5.276	1.0540	1.0397	0.9994	1.0398	1.0357	0.9944	0.9882
ROOM	FE	Spine1	L1L2	4	0.9012	-2.651	1.0359	0.8858	0.9986	1.0167	0.9976	0.9184	0.9921
ROOM	FE	Spine2	L1L2	4	1.0061	0.9155	1.0061	0.9155	1.0066	1.0457	1.0066	1.0457	0.9738
ROOM	FE	Spine2	L3L4	4	0.9969	1.4310	0.9969	1.4310	1.0021	0.8939	1.0021	0.8939	0.9816
ROOM	FE	Spine2	L3L4	4	0.9616	1.3032	0.9616	1.3032	0.9767	1.0225	0.9767	1.0225	0.9846
ROOM	FE	Spine3	L1L2	4	1.9929	-33.86	0.3141	-.7411	1.3475	1.0290	0.4610	1.0614	0.9597
ROOM	FE	Spine3	L1L2	4	2.0869	-35.23	0.3165	-1.179	1.1444	0.9825	0.4635	1.0341	0.9636
ROOM	FE	Spine4	L5S1	4	0.2913	1.9394	2.0100	-1.150	0.3616	0.9903	1.2988	0.9489	1.0219
ROOM	FE	Spine5	L3L4	4	1.0653	0.8939	1.0653	0.8939	0.9674	1.0925	0.9674	1.0925	0.9854
ROOM	FE	Spine7	L5S1	4	0.4012	-.0876	1.8167	3.5546	2.1015	1.8056	0.3200	0.4268	0.9566
ROOM	FE	Spine7	L5S1	4	0.4147	-.1214	2.0415	3.6554	2.1176	1.7915	0.2972	0.4780	0.9715
ROOM	FE	Spine8	L1L2	4	0.2100	-7.721	5.0614	-.0876	0.2559	0.1260	2.5802	2.5806	0.9743
ROOM	FE	Spine8	L3L4	4	1.0015	1.0034	1.0015	1.0034	1.0040	1.0305	1.0040	1.0305	0.9831
ROOM	FE	Spine1	L1L2	6	1.0220	-.8521	0.9849	0.7328	1.0114	1.0389	0.9575	0.9377	0.9840
ROOM	FE	Spine1	L1L2	6	1.0476	1.2808	0.9934	0.7854	0.9976	0.9964	0.9206	1.1140	0.9849
ROOM	FE	Spine2	L1L2	6	1.1058	0.6319	1.1058	0.6319	0.9208	1.0575	0.9208	1.0575	0.9255
ROOM	FE	Spine2	L1L2	6	1.0355	0.8655	1.0355	0.8655	0.9579	1.0632	0.9579	1.0632	0.9787
ROOM	FE	Spine2	L3L4	6	0.9768	1.4657	0.9768	1.4657	0.9939	0.8821	0.9939	0.8821	0.9724

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine2	L3L4	6	0.9433	1.3816	0.9433	1.3816	0.9454	1.0399	0.9454	1.0399	0.9768
ROOM	FE	Spine3	L1L2	6	2.3415	-36.76	0.3080	-1.018	0.2734	1.1831	2.1639	1.0021	0.9570
ROOM	FE	Spine3	L1L2	6	0.4991	19.087	1.3983	1.9542	0.2769	1.1219	1.8530	0.9260	0.9574
ROOM	FE	Spine4	L5S1	6	2.2787	-1.978	0.4230	2.0172	1.5662	0.9442	0.1341	0.6059	1.0187
ROOM	FE	Spine4	L5S1	6	0.2887	1.7087	2.1565	-1.418	0.3638	0.8925	0.6738	1.0285	1.0225
ROOM	FE	Spine5	L3L4	6	1.0404	1.0011	1.0404	1.0011	0.9849	1.0036	0.9849	1.0036	0.9814
ROOM	FE	Spine7	L5S1	6	0.4028	-.1513	1.9261	3.5195	0.4968	0.5882	1.2756	1.2828	0.9364
ROOM	FE	Spine7	L5S1	6	1.3390	1.5272	0.6168	-.3311	2.2554	1.7770	0.3055	0.4611	0.9469
ROOM	FE	Spine8	L1L2	6	0.2162	-8.952	4.1904	-.1378	0.2682	0.0680	1.9695	2.7807	0.9646
ROOM	FE	Spine8	L1L2	6	0.9027	0.3138	0.9786	0.9686	0.2777	0.1952	1.8210	2.6965	0.9693
ROOM	FE	Spine8	L3L4	6	0.9997	0.9699	0.9997	0.9699	0.9901	1.0224	0.9901	1.0224	0.9762
ROOM	FE	Spine8	L3L4	6	0.9964	0.8782	0.9964	0.8782	0.9682	0.9729	0.9682	0.9729	0.9859
ROOM	FE	Spine1	L1L2	8	1.0438	-4.871	0.9960	0.7407	1.0430	1.0935	0.9104	0.9265	0.9814
ROOM	FE	Spine1	L1L2	8	2.1080	1.5548	1.0196	0.5177	1.1318	1.2532	0.9196	0.4926	0.9834
ROOM	FE	Spine2	L1L2	8	0.9758	0.7814	0.9758	0.7814	0.9136	1.0603	0.9136	1.0603	0.9795
ROOM	FE	Spine2	L3L4	8	0.9776	1.5979	0.9776	1.5979	0.9390	0.8870	0.9390	0.8870	0.9684
ROOM	FE	Spine2	L3L4	8	0.9708	1.4852	0.9708	1.4852	0.9328	0.9398	0.9327	0.9398	0.9759
ROOM	FE	Spine3	L1L2	8	0.5081	17.866	1.3897	1.8814	0.2759	1.1690	1.8857	0.9642	0.9513
ROOM	FE	Spine3	L1L2	8	2.3673	-33.48	0.3109	-1.060	0.2684	1.1302	2.2733	1.0533	0.9524
ROOM	FE	Spine4	L5S1	8	0.3074	2.5611	2.2755	-1.335	2.1213	0.8769	0.1953	1.1323	1.0173
ROOM	FE	Spine4	L5S1	8	0.2714	-.6460	1.5378	-.9983	0.7689	0.7999	0.2356	1.2459	1.0187
ROOM	FE	Spine5	L3L4	8	1.1370	0.5825	1.1370	0.5825	0.9735	1.3219	0.9735	1.3219	0.9720
ROOM	FE	Spine7	L5S1	8	1.1578	1.4330	0.6176	-.5217	0.4548	0.6049	1.1421	1.1933	0.8792
ROOM	FE	Spine7	L5S1	8	0.3950	-.2200	1.8067	3.3801	0.4271	0.6116	1.3746	1.1998	0.8811
ROOM	FE	Spine8	L1L2	8	0.2058	-8.540	5.1480	-.0445	0.2644	0.3319	2.2491	2.5139	0.9635
ROOM	FE	Spine8	L3L4	8	1.0042	0.9154	1.0042	0.9154	0.9987	1.0175	0.9987	1.0175	0.9757
ROOM	FE	Spine1	L1L2	10	1.0440	-5.070	0.9754	0.6396	1.0484	1.0881	0.9191	0.9083	0.9840
ROOM	FE	Spine1	L1L2	10	1.0323	-9.451	0.9827	0.6494	1.0127	1.0978	1.0351	0.8995	0.9873
ROOM	FE	Spine2	L1L2	10	1.0622	0.7349	1.0622	0.7349	0.9513	1.0317	0.9513	1.0317	0.9684
ROOM	FE	Spine2	L1L2	10	1.2858	0.8246	1.2858	0.8246	1.1769	1.0622	1.1769	1.0622	0.9888
ROOM	FE	Spine2	L3L4	10	0.9675	1.5290	0.9675	1.5290	0.9688	0.9468	0.9688	0.9468	0.9645
ROOM	FE	Spine2	L3L4	10	0.9577	1.5558	0.9577	1.5558	0.9468	0.9603	0.9467	0.9603	0.9747
ROOM	FE	Spine3	L1L2	10	0.5080	18.845	1.3369	1.8830	0.2777	1.2109	1.9632	0.9569	0.9500

TEMP	Dir	SPINE	SEGMENT	RATE	Ua1	Um1	Ua2	Um2	La1	Lm1	La2	Lm2	ROM
ROOM	FE	Spine3	L1L2	10	0.5133	15.205	1.3553	1.9408	1.2226	1.0665	0.4751	1.2286	0.9502
ROOM	FE	Spine4	L5S1	10	0.3209	1.7663	2.0431	-.9382	0.3290	1.0686	0.8764	0.9256	1.0174
ROOM	FE	Spine4	L5S1	10	0.3744	4.0712	1.1378	-3.573	1.4610	0.9185	0.1856	1.1820	1.0191
ROOM	FE	Spine5	L3L4	10	1.0006	1.0219	1.0006	1.0219	0.9505	0.9805	0.9505	0.9805	0.9833
ROOM	FE	Spine7	L5S1	10	1.3569	1.4604	0.5397	-.9362	2.0014	1.7150	0.2411	0.3573	0.9130
ROOM	FE	Spine7	L5S1	10	0.3830	-.0637	1.9000	3.5811	1.6878	1.7236	0.2464	0.5885	0.9590
ROOM	FE	Spine8	L1L2	10	0.2159	-10.06	4.4481	-.1229	1.1960	1.6232	0.3917	0.5090	0.9603
ROOM	FE	Spine8	L1L2	10	1.0346	0.6890	1.0492	1.1862	0.2625	0.2611	2.0779	2.6654	0.9695
ROOM	FE	Spine8	L3L4	10	1.0065	0.8555	1.0065	0.8555	0.9942	1.0082	0.9942	1.0082	0.9727
ROOM	FE	Spine8	L3L4	10	0.9894	0.9044	0.9894	0.9044	1.0032	1.0374	1.0032	1.0374	0.9793
ROOM	FE	Spine1	L1L2	12	0.1971	30.378	4.4412	-.0627	1.0111	1.0583	0.9773	1.0735	0.9860
ROOM	FE	Spine1	L1L2	12	1.0748	-11.77	0.9435	0.4991	1.0553	1.1070	0.9555	0.9490	0.9909
ROOM	FE	Spine2	L1L2	12	1.1552	0.6655	1.1552	0.6655	0.9610	1.0465	0.9610	1.0465	0.9417
ROOM	FE	Spine2	L3L4	12	1.0183	1.5586	1.0183	1.5586	0.9104	0.9771	0.9103	0.9771	0.9707
ROOM	FE	Spine2	L3L4	12	0.9891	1.5466	0.9891	1.5466	0.8186	0.9390	0.8186	0.9390	0.9709
ROOM	FE	Spine3	L1L2	12	0.5328	22.196	1.3451	1.9013	0.2744	1.2212	2.2286	0.9870	0.9478
ROOM	FE	Spine3	L1L2	12	0.5095	19.667	1.3755	1.9247	1.2302	1.0623	0.4754	1.1988	0.9505
ROOM	FE	Spine4	L5S1	12	0.3059	2.1984	2.2301	-1.746	0.3522	1.1508	1.2962	0.9606	1.0125
ROOM	FE	Spine4	L5S1	12	0.2731	-1.653	1.6093	-.1943	0.3308	0.9248	0.6145	1.1852	1.0211
ROOM	FE	Spine5	L3L4	12	0.9685	1.3124	0.9685	1.3124	0.9704	0.8618	0.9704	0.8618	0.9889
ROOM	FE	Spine7	L5S1	12	1.3530	1.4703	0.6271	-.2865	1.6574	1.7036	0.2708	0.5596	0.9048
ROOM	FE	Spine7	L5S1	12	0.3877	-.0986	1.6474	3.4411	1.2905	1.6537	0.2534	0.6065	0.9398
ROOM	FE	Spine8	L1L2	12	0.2102	-9.811	4.8290	-.0158	0.2613	0.2202	1.7856	2.9539	0.9605
ROOM	FE	Spine8	L3L4	12	1.0113	0.8753	1.0113	0.8753	0.9855	1.0291	0.9855	1.0291	0.9713
ROOM	FE	Spine1	L1L2	14	1.1657	-13.03	0.9444	0.4269	0.9742	1.0843	0.8111	1.2366	0.9956
ROOM	FE	Spine2	L1L2	14	1.0709	0.5203	1.0709	0.5203	0.8068	1.2368	0.8068	1.2368	0.9612
ROOM	FE	Spine2	L3L4	14	1.0213	1.6094	1.0213	1.6094	0.9480	1.0001	0.9480	1.0001	0.9713
ROOM	FE	Spine3	L1L2	14	0.5086	20.727	1.4804	1.7854	0.2858	1.2904	2.0227	1.0091	0.9515
ROOM	FE	Spine4	L5S1	14	0.2697	0.8190	2.1299	-.6981	0.3354	1.2201	1.0049	1.0358	1.0232
ROOM	FE	Spine7	L5S1	14	0.3942	-.2055	1.7214	3.2473	0.3841	0.8101	0.8558	1.1545	0.8924
ROOM	FE	Spine8	L1L2	14	0.8299	0.3619	1.1028	1.2148	0.2625	0.4889	1.5994	2.8885	0.9486
ROOM	FE	Spine8	L3L4	14	1.0275	0.8332	1.0275	0.8332	1.0021	1.0355	1.0021	1.0355	0.9703

C.3.4. Rate-Targeted Effect Flexibility Parameters

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine1	L1L2	0.25	1.0156	1.0257	1.0103	0.9949	1.0100	1.0466	1.0274	1.0192	1.0229
ROOM	FE	Spine1	L1L2	0.5	1.0054	0.9842	0.9837	0.9784	0.9789	1.0161	1.0147	1.0129	1.0137
ROOM	FE	Spine1	L1L2	0.5	1.0071	1.0128	1.0453	1.0381	1.0057	1.0618	1.0212	0.9990	1.0089
ROOM	FE	Spine1	L1L2	2	0.9948	1.0212	0.9769	0.9821	1.0266	1.0110	1.0298	1.0379	1.0343
ROOM	FE	Spine1	L1L2	2	0.9968	1.0067	0.9242	0.9273	1.0100	0.9551	0.9911	1.0583	1.0283
ROOM	FE	Spine1	L1L2	4	0.9882	1.0481	1.0297	1.0421	1.0606	1.0491	1.1117	1.0152	1.0583
ROOM	FE	Spine1	L1L2	4	0.9921	1.0534	0.9735	0.9813	1.0619	0.9983	1.0723	1.0141	1.0401
ROOM	FE	Spine1	L1L2	6	0.9840	1.1340	1.0389	1.0559	1.1525	1.0898	0.9819	1.0864	1.0398
ROOM	FE	Spine1	L1L2	6	0.9849	1.1113	1.0919	1.1087	1.1283	1.1482	0.9722	1.0637	1.0229
ROOM	FE	Spine1	L1L2	8	0.9814	1.2100	1.0958	1.1166	1.2330	1.2091	0.9834	1.1941	1.1001
ROOM	FE	Spine1	L1L2	8	0.9834	1.3046	1.1240	1.1431	1.3267	1.1761	0.5342	1.6277	1.1396
ROOM	FE	Spine1	L1L2	10	0.9840	1.2476	1.1139	1.1322	1.2680	1.2218	0.9759	1.1939	1.0966
ROOM	FE	Spine1	L1L2	10	0.9873	1.2774	1.1752	1.1904	1.2938	1.2345	0.9997	1.1669	1.0923
ROOM	FE	Spine1	L1L2	12	0.9860	1.3641	1.1956	1.2127	1.3835	1.3108	1.0908	1.1168	1.1052
ROOM	FE	Spine1	L1L2	12	0.9909	1.3948	1.2752	1.2870	1.4077	1.4022	0.9814	1.2576	1.1343
ROOM	FE	Spine1	L1L2	14	0.9956	1.5040	1.4036	1.4100	1.5107	1.6232	0.9439	1.2825	1.1314
BODY	FE	Spine1	L3L4	0.5	1.1398	1.0543	1.0677	0.9373	0.9254	0.9152	0.8399	0.8589	0.8492
BODY	FE	Spine1	L3L4	2	0.9537	1.0453	1.0656	1.1179	1.0965	1.0898	0.9875	1.0334	1.0100
BODY	FE	Spine1	L3L4	4	0.8596	1.0818	1.0927	1.2718	1.2590	1.2535	1.1090	1.1557	1.1319
BODY	FE	Spine1	L3L4	6	0.8480	0.7447	0.7651	0.9027	0.8785	0.8882	1.1006	1.2384	1.1681
BODY	FE	Spine1	L3L4	8	0.7433	1.1253	1.1617	1.5637	1.5146	1.4810	1.2295	1.2834	1.2559
BODY	FE	Spine1	L3L4	10	0.7992	0.9097	0.9291	1.1631	1.1387	1.1267	1.1793	1.2191	1.1988
BODY	FE	Spine1	L3L4	12	0.8273	0.8998	0.8906	1.0771	1.0881	1.0918	1.2157	1.2161	1.2159
BODY	FE	Spine1	L5S1	0.5	1.0451	1.0572	1.0103	0.9668	1.0117	1.0547	0.8893	1.0843	0.9844
BODY	FE	Spine1	L5S1	2	0.9873	1.0244	0.9878	1.0007	1.0378	0.9731	1.1081	1.0835	1.0961
BODY	FE	Spine1	L5S1	4	0.9168	0.8871	0.9025	0.9845	0.9677	1.0088	0.9494	1.1634	1.0538
BODY	FE	Spine1	L5S1	6	0.9604	0.8882	0.9001	0.9373	0.9250	0.9271	0.9223	0.9979	0.9591
BODY	FE	Spine1	L5S1	8	0.8357	0.9032	0.8796	1.0526	1.0809	1.0717	1.0872	1.1786	1.1318
BODY	FE	Spine1	L5S1	10	0.8963	0.7266	0.6780	0.7566	0.8108	0.8307	1.1307	1.1615	1.1457
BODY	FE	Spine1	L5S1	12	1.0000	0.7701	0.7397	0.7398	0.7703	0.7825	0.9815	0.9981	0.9896
ROOM	FE	Spine2	L1L2	2	0.9927	1.0316	1.0462	1.0539	1.0392	1.0405	0.9889	0.9963	0.9928
ROOM	FE	Spine2	L1L2	4	0.9738	1.1172	1.1125	1.1423	1.1472	1.1493	1.0262	1.0258	1.0260
ROOM	FE	Spine2	L1L2	6	0.9255	1.2840	1.2915	1.3954	1.3874	1.3902	0.9938	1.1939	1.0997

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine2	L1L2	6	0.9787	1.1904	1.1825	1.2083	1.2164	1.2175	0.9947	1.0757	1.0376
ROOM	FE	Spine2	L1L2	8	0.9795	1.2497	1.1760	1.2006	1.2758	1.2793	1.0545	1.1262	1.0924
ROOM	FE	Spine2	L1L2	10	0.9684	1.2223	1.2257	1.2657	1.2622	1.2644	0.9828	1.0971	1.0433
ROOM	FE	Spine2	L1L2	10	0.9888	1.2348	1.4730	1.4897	1.2489	1.2516	0.8043	0.8787	0.8436
ROOM	FE	Spine2	L1L2	12	0.9417	1.2643	1.3251	1.4072	1.3426	1.3454	0.9356	1.1249	1.0358
ROOM	FE	Spine2	L1L2	14	0.9612	1.7167	1.5703	1.6338	1.7861	1.7974	1.0020	1.3303	1.1757
ROOM	FE	Spine2	L3L4	0.25	1.0317	1.0732	1.0547	1.0224	1.0404	1.0413	1.0483	0.9590	1.0115
ROOM	FE	Spine2	L3L4	0.5	1.0152	1.0255	0.9945	0.9797	1.0103	1.0086	1.0009	1.0249	1.0108
ROOM	FE	Spine2	L3L4	0.5	1.0215	1.0718	1.0415	1.0197	1.0494	1.0481	0.9803	1.0155	0.9949
ROOM	FE	Spine2	L3L4	2	0.9852	0.9689	0.9864	1.0014	0.9837	0.9850	1.0163	0.9889	1.0050
ROOM	FE	Spine2	L3L4	2	0.9916	1.0628	1.0508	1.0599	1.0719	1.0718	1.0224	1.0062	1.0157
ROOM	FE	Spine2	L3L4	4	0.9816	1.0178	1.0120	1.0311	1.0370	1.0368	1.0241	1.0187	1.0219
ROOM	FE	Spine2	L3L4	4	0.9846	1.0793	1.0377	1.0541	1.0964	1.0954	1.0605	1.0442	1.0537
ROOM	FE	Spine2	L3L4	6	0.9724	1.0084	0.9933	1.0217	1.0372	1.0379	1.0543	1.0362	1.0468
ROOM	FE	Spine2	L3L4	6	0.9768	1.1030	1.0313	1.0559	1.1293	1.1304	1.0898	1.0873	1.0888
ROOM	FE	Spine2	L3L4	8	0.9684	1.0414	0.9876	1.0201	1.0756	1.0774	1.0576	1.1010	1.0755
ROOM	FE	Spine2	L3L4	8	0.9759	1.0579	0.9962	1.0210	1.0841	1.0841	1.0567	1.0999	1.0745
ROOM	FE	Spine2	L3L4	10	0.9645	1.0618	1.0175	1.0551	1.1011	1.1022	1.0759	1.0746	1.0754
ROOM	FE	Spine2	L3L4	10	0.9747	1.0893	1.0254	1.0522	1.1177	1.1191	1.0753	1.0877	1.0804
ROOM	FE	Spine2	L3L4	12	0.9707	1.0984	1.0283	1.0594	1.1317	1.1326	1.0161	1.1365	1.0658
ROOM	FE	Spine2	L3L4	12	0.9709	1.0664	0.9390	0.9673	1.0986	1.1011	1.0384	1.2544	1.1275
ROOM	FE	Spine2	L3L4	14	0.9713	1.1290	1.0758	1.1078	1.1625	1.1619	1.0170	1.0955	1.0494
BODY	FE	Spine2	L5S1	0.25	1.0808	1.2086	1.1605	1.0733	1.1183	1.1482	0.9236	0.8875	0.9043
BODY	FE	Spine2	L5S1	0.5	1.0386	1.0922	1.0491	1.0098	1.0518	1.0761	1.0096	0.9748	0.9910
BODY	FE	Spine2	L5S1	0.5	1.0489	1.1089	1.0505	1.0011	1.0573	1.0834	0.9230	0.9734	0.9500
BODY	FE	Spine2	L5S1	2	0.9731	0.9398	0.9620	0.9882	0.9658	0.9490	1.0144	1.0089	1.0115
BODY	FE	Spine2	L5S1	2	0.9998	0.9675	0.9362	0.9360	0.9677	0.9668	0.9885	1.0012	0.9953
BODY	FE	Spine2	L5S1	4	0.9735	0.9109	0.8413	0.8638	0.9357	0.8381	1.0875	1.0416	1.0630
BODY	FE	Spine2	L5S1	6	0.9543	0.9611	0.9604	1.0061	1.0073	0.9579	1.0818	1.0745	1.0779
BODY	FE	Spine2	L5S1	6	0.9574	0.9561	0.9206	0.9612	0.9987	0.9393	1.0413	1.0330	1.0369
BODY	FE	Spine2	L5S1	10	0.9467	1.0164	0.9710	1.0253	1.0737	1.0356	1.0383	1.0600	1.0499
BODY	FE	Spine2	L5S1	10	0.9508	0.9204	0.9050	0.9515	0.9681	0.9215	1.0860	1.1280	1.1084
BODY	FE	Spine2	L5S1	12	0.9399	1.0591	0.9899	1.0528	1.1270	1.0753	1.0273	1.1052	1.0689

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	FE	Spine2	L5S1	14	0.9469	1.0525	1.0271	1.0843	1.1117	1.0745	1.0675	1.0743	1.0711
ROOM	FE	Spine3	L1L2	0.25	1.0552	1.1329	1.0924	1.0355	1.0737	1.0382	0.9818	0.9269	0.9579
ROOM	FE	Spine3	L1L2	0.5	1.0270	1.0882	1.1059	1.0771	1.0597	1.0588	0.9868	0.9261	0.9604
ROOM	FE	Spine3	L1L2	0.5	1.0377	1.0029	1.0656	1.0271	0.9664	0.9781	0.8932	0.9329	0.9105
ROOM	FE	Spine3	L1L2	2	0.9709	0.9600	0.9226	0.9504	0.9888	0.9912	1.0390	1.1095	1.0697
ROOM	FE	Spine3	L1L2	2	0.9798	1.0060	1.0562	1.0782	1.0268	1.1076	1.0772	1.0092	1.0477
ROOM	FE	Spine3	L1L2	4	0.9597	0.9648	1.0521	1.0965	1.0054	1.1208	1.0865	1.0244	1.0595
ROOM	FE	Spine3	L1L2	4	0.9636	0.9781	0.9549	0.9911	1.0150	1.0569	1.0599	1.1471	1.0978
ROOM	FE	Spine3	L1L2	6	0.9570	1.0266	1.0662	1.1144	1.0728	1.1133	1.0028	1.0900	1.0407
ROOM	FE	Spine3	L1L2	6	0.9574	1.0075	0.9936	1.0380	1.0524	1.0851	0.9945	1.2152	1.0904
ROOM	FE	Spine3	L1L2	8	0.9513	1.0494	1.0738	1.1289	1.1032	1.1884	1.0114	1.2200	1.1021
ROOM	FE	Spine3	L1L2	8	0.9524	1.0591	1.1960	1.2560	1.1120	1.2559	1.0194	1.0756	1.0438
ROOM	FE	Spine3	L1L2	10	0.9500	1.0741	1.0838	1.1410	1.1307	1.2071	1.0470	1.1880	1.1083
ROOM	FE	Spine3	L1L2	10	0.9502	1.1086	1.1719	1.2336	1.1667	1.2785	1.0442	1.1381	1.0850
ROOM	FE	Spine3	L1L2	12	0.9478	1.1206	1.1835	1.2489	1.1824	1.2879	1.0776	1.0981	1.0865
ROOM	FE	Spine3	L1L2	12	0.9505	1.1305	1.1863	1.2483	1.1894	1.2935	1.0538	1.1332	1.0883
ROOM	FE	Spine3	L1L2	14	0.9515	1.1833	1.2551	1.3193	1.2437	1.3592	1.0141	1.1820	1.0871
BODY	FE	Spine3	L5S1	0.25	1.0381	1.1474	1.0446	1.0063	1.1052	1.1119	1.1475	1.0474	1.0930
BODY	FE	Spine3	L5S1	0.5	1.0081	1.0386	0.9966	0.9886	1.0302	1.0361	1.0338	0.9926	1.0114
BODY	FE	Spine3	L5S1	0.5	1.0311	1.1059	1.0319	1.0008	1.0725	1.0773	1.0437	0.9805	1.0093
BODY	FE	Spine3	L5S1	2	1.0045	1.0310	1.0136	1.0091	1.0263	1.0316	0.9437	0.9740	0.9602
BODY	FE	Spine3	L5S1	4	0.9925	0.9767	0.9927	1.0003	0.9840	0.9736	0.9326	1.1042	1.0260
BODY	FE	Spine3	L5S1	4	1.0042	1.0318	1.0156	1.0114	1.0274	1.0316	1.0057	1.0068	1.0063
BODY	FE	Spine3	L5S1	6	0.9930	0.9944	0.9920	0.9991	1.0014	0.9914	0.9576	1.0820	1.0253
BODY	FE	Spine3	L5S1	6	0.9940	1.0573	1.0160	1.0223	1.0636	1.0628	1.0576	1.0661	1.0622
BODY	FE	Spine3	L5S1	8	0.9915	1.0016	1.0093	1.0180	1.0102	1.0015	1.0446	1.0939	1.0714
BODY	FE	Spine3	L5S1	8	0.9918	1.0709	1.0335	1.0421	1.0797	1.0918	1.2542	1.0906	1.1652
BODY	FE	Spine3	L5S1	10	0.9895	1.0709	1.0262	1.0371	1.0822	1.0862	1.0978	1.1146	1.1070
BODY	FE	Spine3	L5S1	10	0.9950	1.0436	1.0208	1.0260	1.0488	1.0394	1.0309	1.1908	1.1179
BODY	FE	Spine3	L5S1	12	0.9852	1.0518	1.0454	1.0612	1.0675	1.0907	1.1744	1.3580	1.2743
BODY	FE	Spine3	L5S1	12	0.9859	1.1280	1.0667	1.0820	1.1441	1.2000	1.7338	1.4119	1.5586
BODY	FE	Spine3	L5S1	14	0.9870	1.1142	1.0449	1.0588	1.1288	1.1398	1.1818	1.2615	1.2251
BODY	FE	Spine4	L1L2	0.25	1.0373	0.7228	0.6318	0.6093	0.6969	0.6958	1.3448	0.9606	1.1364

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
BODY	FE	Spine4	L1L2	0.5	1.0065	0.9691	1.0057	0.9997	0.9630	0.9630	1.0166	0.8741	0.9393
BODY	FE	Spine4	L1L2	0.5	1.0269	1.0741	1.0865	1.0585	1.0462	1.0437	0.9934	0.9063	0.9461
BODY	FE	Spine4	L1L2	2	0.9873	1.0259	0.9929	1.0061	1.0393	1.0412	1.0631	1.0106	1.0346
BODY	FE	Spine4	L1L2	2	0.9951	1.0266	0.9915	0.9969	1.0318	1.0336	1.0419	1.0304	1.0357
BODY	FE	Spine4	L1L2	4	0.9719	1.0531	0.9800	1.0088	1.0837	1.0815	1.0981	1.1098	1.1045
BODY	FE	Spine4	L1L2	4	0.9836	1.0154	0.9822	0.9990	1.0325	1.0336	1.0447	1.0551	1.0504
BODY	FE	Spine4	L1L2	6	0.9682	1.0143	0.9053	0.9355	1.0478	1.0462	1.1736	1.1293	1.1496
BODY	FE	Spine4	L1L2	6	0.9717	1.0854	0.9573	0.9856	1.1173	1.1193	1.1510	1.1940	1.1743
BODY	FE	Spine4	L1L2	8	0.9673	1.0496	0.9568	0.9896	1.0853	1.0866	1.1239	1.1469	1.1364
BODY	FE	Spine4	L1L2	8	0.9685	1.0578	0.9629	0.9947	1.0925	1.0941	1.1240	1.1469	1.1364
BODY	FE	Spine4	L1L2	10	0.9620	1.1125	0.9604	0.9987	1.1567	1.1571	1.2118	1.1827	1.1960
BODY	FE	Spine4	L1L2	10	0.9684	1.0976	1.0300	1.0641	1.1336	1.1345	1.0908	1.0987	1.0951
BODY	FE	Spine4	L1L2	12	0.9678	1.1583	1.0773	1.1136	1.1972	1.1975	1.0664	1.1680	1.1216
BODY	FE	Spine4	L1L2	12	0.9696	1.1454	1.0563	1.0899	1.1816	1.1824	1.0930	1.1400	1.1185
BODY	FE	Spine4	L1L2	14	0.9553	1.1723	1.0911	1.1426	1.2273	1.2277	1.0937	1.1467	1.1225
ROOM	FE	Spine4	L5S1	0.25	1.0546	1.0689	1.0762	1.0214	1.0129	1.0099	0.9643	0.9381	0.9542
ROOM	FE	Spine4	L5S1	0.5	1.0418	1.2914	1.0776	1.0353	1.2388	1.2574	0.9696	1.2271	1.0687
ROOM	FE	Spine4	L5S1	0.5	1.0448	1.0471	1.0495	1.0054	1.0015	1.0132	0.8789	0.8768	0.8781
ROOM	FE	Spine4	L5S1	2	1.0303	0.9973	0.9805	0.9525	0.9674	1.0066	0.8385	0.9159	0.8683
ROOM	FE	Spine4	L5S1	4	1.0219	1.0794	1.0349	1.0136	1.0556	1.0660	0.8972	0.9712	0.9257
ROOM	FE	Spine4	L5S1	6	1.0187	0.8489	0.8616	0.8465	0.8328	1.0050	0.6958	1.2716	0.9172
ROOM	FE	Spine4	L5S1	6	1.0225	1.0915	0.9981	0.9770	1.0668	1.0990	0.8491	1.0661	0.9325
ROOM	FE	Spine4	L5S1	8	1.0173	1.0878	1.0309	1.0142	1.0687	1.0759	0.9677	0.9935	0.9777
ROOM	FE	Spine4	L5S1	8	1.0187	1.2299	0.9978	0.9804	1.2066	1.2013	0.8595	1.3490	1.0478
ROOM	FE	Spine4	L5S1	10	1.0174	1.1035	1.0264	1.0097	1.0838	1.0875	0.8093	1.2193	0.9669
ROOM	FE	Spine4	L5S1	10	1.0191	1.2101	0.9807	0.9631	1.1866	1.2046	1.1149	1.0448	1.0879
ROOM	FE	Spine4	L5S1	12	1.0125	1.1952	1.0691	1.0568	1.1797	1.1931	1.0842	1.5620	1.2680
ROOM	FE	Spine4	L5S1	12	1.0211	1.2710	1.0187	0.9985	1.2440	1.2492	0.8638	1.2240	1.0024
ROOM	FE	Spine4	L5S1	14	1.0232	1.2876	1.0952	1.0713	1.2576	1.2706	0.9360	1.5039	1.1544
BODY	FE	Spine5	L1L2	0.25	1.0523	1.0210	1.1578	1.1004	0.9705	1.0537	0.8309	1.0925	0.9001
BODY	FE	Spine5	L1L2	0.5	1.0465	1.0466	1.1339	1.0836	1.0002	1.0980	0.9836	1.1140	1.0181
BODY	FE	Spine5	L1L2	2	1.0046	0.9614	0.9001	0.8960	0.9571	0.8065	0.7265	1.1465	0.8377
BODY	FE	Spine5	L1L2	4	0.9809	0.7394	0.5412	0.5518	0.7539	0.5115	0.6231	1.3022	0.8028

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine5	L3L4	0.5	1.0139	1.0741	1.0414	1.0274	1.0597	1.0629	1.0175	1.0184	1.0179
ROOM	FE	Spine5	L3L4	2	0.9975	0.8861	0.8689	0.8712	0.8885	0.8935	1.0189	1.0434	1.0313
ROOM	FE	Spine5	L3L4	4	0.9854	1.3176	1.3470	1.3673	1.3375	1.3376	0.9582	1.0560	1.0078
ROOM	FE	Spine5	L3L4	6	0.9814	0.9861	1.0109	1.0303	1.0051	1.0090	0.9790	1.0351	1.0075
ROOM	FE	Spine5	L3L4	8	0.9720	2.1778	2.2078	2.2720	2.2413	2.2465	0.9350	1.0928	1.0151
ROOM	FE	Spine5	L3L4	10	0.9833	0.9102	0.9044	0.9200	0.9259	0.9294	1.0145	1.0686	1.0419
ROOM	FE	Spine5	L3L4	12	0.9889	0.2947	0.2949	0.2983	0.2981	0.2978	1.0362	1.0350	1.0356
BODY	FE	Spine6	L3L4	0.5	1.0832	1.0720	1.0643	0.9826	0.9896	1.0000	0.9488	0.9344	0.9417
BODY	FE	Spine6	L3L4	2	0.9720	0.9910	0.9848	1.0131	1.0195	1.0268	1.0354	1.0486	1.0419
BODY	FE	Spine6	L3L4	4	0.8583	0.9887	1.0029	1.1685	1.1520	1.1391	1.1460	1.1272	1.1367
BODY	FE	Spine6	L3L4	6	0.9117	0.9422	0.9205	1.0097	1.0335	1.0659	1.1603	1.1571	1.1587
BODY	FE	Spine6	L3L4	8	0.6681	0.9681	1.0495	1.5710	1.4492	1.3391	1.2983	1.2464	1.2726
BODY	FE	Spine6	L3L4	10	0.8655	0.8806	0.8903	1.0286	1.0174	1.0138	1.1783	1.1168	1.1479
BODY	FE	Spine6	L3L4	12	0.9345	0.9569	0.9319	0.9972	1.0240	1.0594	1.1455	1.1313	1.1385
BODY	FE	Spine7	L1L2	0.25	1.0638	1.1750	1.1029	1.0352	1.1046	1.1316	1.0645	0.9824	1.0321
BODY	FE	Spine7	L1L2	0.5	1.0096	1.0189	1.0497	1.0382	1.0092	1.0139	0.9879	0.9615	0.9775
BODY	FE	Spine7	L1L2	0.5	1.0360	1.1627	1.1187	1.0784	1.1224	1.1540	1.0820	0.9439	1.0276
BODY	FE	Spine7	L1L2	2	0.9787	1.0050	1.0159	1.0365	1.0269	1.0193	1.0029	1.0194	1.0094
BODY	FE	Spine7	L1L2	2	0.9870	0.9536	0.9218	0.9326	0.9662	0.9422	0.9832	1.1267	1.0397
BODY	FE	Spine7	L1L2	4	0.9334	0.9732	1.0841	1.1598	1.0426	1.0738	1.0137	0.9832	1.0017
BODY	FE	Spine7	L1L2	6	0.9310	0.9790	1.0393	1.1148	1.0516	1.0150	0.8718	1.2082	1.0044
BODY	FE	Spine7	L1L2	6	0.9359	0.9475	1.0049	1.0722	1.0124	0.9775	0.8905	1.1651	0.9987
BODY	FE	Spine7	L1L2	8	0.9382	0.9762	1.0759	1.1452	1.0405	1.0535	0.9263	1.0626	0.9800
BODY	FE	Spine7	L1L2	10	0.9069	0.8671	0.8616	0.9486	0.9561	0.9358	1.0364	1.0272	1.0328
BODY	FE	Spine7	L1L2	10	0.9459	1.0058	1.0578	1.1166	1.0633	1.0909	0.9435	1.1325	1.0180
BODY	FE	Spine7	L1L2	12	0.9368	1.0033	1.1076	1.1807	1.0711	1.1048	0.9324	1.0167	0.9656
BODY	FE	Spine7	L1L2	14	0.9304	1.0421	1.1392	1.2227	1.1201	1.1711	0.9669	1.1207	1.0275
ROOM	FE	Spine7	L5S1	0.25	1.0454	1.1179	1.0696	1.0234	1.0696	1.0637	1.0258	0.8859	0.9701
ROOM	FE	Spine7	L5S1	0.5	1.0148	1.0302	1.0231	1.0084	1.0156	1.0149	1.0258	1.0116	1.0201
ROOM	FE	Spine7	L5S1	0.5	1.0336	1.0554	1.0463	1.0125	1.0214	1.0127	0.9855	0.9310	0.9638
ROOM	FE	Spine7	L5S1	2	0.9608	0.9555	0.9852	1.0257	0.9949	0.9692	0.9982	1.2721	1.1072
ROOM	FE	Spine7	L5S1	2	0.9781	0.9823	1.0163	1.0392	1.0046	1.0064	1.0524	0.9937	1.0290
ROOM	FE	Spine7	L5S1	4	0.9566	0.9624	1.0028	1.0485	1.0064	0.9926	0.9660	1.2328	1.0721

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine7	L5S1	4	0.9715	1.0067	1.0317	1.0622	1.0366	1.0499	1.0773	1.0156	1.0528
ROOM	FE	Spine7	L5S1	6	0.9364	0.9923	1.0023	1.0706	1.0600	1.0180	1.0582	1.2875	1.1495
ROOM	FE	Spine7	L5S1	6	0.9469	1.0009	1.0463	1.1052	1.0575	1.0594	1.0915	1.1343	1.1085
ROOM	FE	Spine7	L5S1	8	0.8792	0.9422	0.8731	0.9933	1.0721	1.0584	1.0768	1.0168	1.0529
ROOM	FE	Spine7	L5S1	8	0.8811	0.9369	0.9463	1.0742	1.0636	1.1051	1.1098	1.0194	1.0738
ROOM	FE	Spine7	L5S1	10	0.9130	1.0000	1.0096	1.1061	1.0956	1.1539	1.3160	1.1172	1.2369
ROOM	FE	Spine7	L5S1	10	0.9590	1.0002	0.9624	1.0037	1.0433	1.0117	0.9246	0.7508	0.8554
ROOM	FE	Spine7	L5S1	12	0.9048	1.0084	0.9761	1.0791	1.1149	1.0817	1.0561	0.8549	0.9761
ROOM	FE	Spine7	L5S1	12	0.9398	1.0131	0.8393	0.8933	1.0784	0.9756	0.8885	0.8217	0.8619
ROOM	FE	Spine7	L5S1	14	0.8924	1.0470	0.8990	1.0077	1.1737	1.0977	0.9957	0.8837	0.9512
ROOM	FE	Spine8	L1L2	0.25	1.0360	1.0656	1.0675	1.0303	1.0286	1.0038	0.9702	0.8645	0.9228
ROOM	FE	Spine8	L1L2	0.5	1.0085	1.0089	1.0475	1.0387	1.0004	1.0010	0.9988	0.9739	0.9876
ROOM	FE	Spine8	L1L2	0.5	1.0164	1.0257	1.0516	1.0346	1.0092	1.0152	0.9785	0.9775	0.9781
ROOM	FE	Spine8	L1L2	2	0.9821	0.9694	0.9087	0.9252	0.9871	0.9910	1.0655	1.1295	1.0943
ROOM	FE	Spine8	L1L2	2	0.9876	1.0181	1.0381	1.0510	1.0308	1.0566	1.0088	1.0447	1.0249
ROOM	FE	Spine8	L1L2	4	0.9743	1.0047	1.0885	1.1171	1.0312	1.0908	1.0621	1.0078	1.0377
ROOM	FE	Spine8	L1L2	6	0.9646	1.0719	0.9865	1.0227	1.1113	1.1507	1.2013	1.1552	1.1806
ROOM	FE	Spine8	L1L2	6	0.9693	1.0638	1.0013	1.0329	1.0975	1.1264	1.0322	1.1560	1.0878
ROOM	FE	Spine8	L1L2	8	0.9635	1.1191	1.0990	1.1405	1.1615	1.1649	1.1421	1.0386	1.0956
ROOM	FE	Spine8	L1L2	10	0.9603	1.2080	1.0393	1.0822	1.2579	1.2576	1.3491	1.1752	1.2710
ROOM	FE	Spine8	L1L2	10	0.9695	1.1733	1.1034	1.1380	1.2102	1.2220	1.2867	1.1208	1.2122
ROOM	FE	Spine8	L1L2	12	0.9605	1.2670	1.1369	1.1836	1.3191	1.3660	1.3298	1.3222	1.3264
ROOM	FE	Spine8	L1L2	14	0.9486	1.2999	1.0701	1.1280	1.3703	1.3859	1.3071	1.2958	1.3021
ROOM	FE	Spine8	L3L4	0.25	1.0286	1.0647	1.0599	1.0303	1.0351	1.0325	1.0162	0.9600	0.9894
ROOM	FE	Spine8	L3L4	0.5	1.0095	1.0008	1.0100	1.0003	0.9913	0.9894	0.9957	0.9748	0.9857
ROOM	FE	Spine8	L3L4	0.5	1.0116	1.0258	1.0461	1.0340	1.0139	1.0156	0.9961	0.9558	0.9769
ROOM	FE	Spine8	L3L4	2	0.9916	1.0057	0.9956	1.0040	1.0142	1.0156	1.0096	1.0240	1.0164
ROOM	FE	Spine8	L3L4	2	0.9991	0.9882	0.9814	0.9821	0.9890	0.9913	1.0047	1.0092	1.0068
ROOM	FE	Spine8	L3L4	4	0.9831	1.0467	1.0464	1.0643	1.0647	1.0662	1.0172	1.0148	1.0160
ROOM	FE	Spine8	L3L4	6	0.9762	1.0619	1.0512	1.0767	1.0877	1.0906	1.0265	1.0366	1.0313
ROOM	FE	Spine8	L3L4	6	0.9859	1.0754	1.0495	1.0644	1.0907	1.0943	1.0195	1.0492	1.0336
ROOM	FE	Spine8	L3L4	8	0.9757	1.1182	1.1110	1.1386	1.1460	1.1487	1.0243	1.0299	1.0270
ROOM	FE	Spine8	L3L4	10	0.9727	1.1677	1.1553	1.1876	1.2004	1.2049	1.0264	1.0390	1.0324

TEMP	Dir	SPINE	SEGMENT	RATE	ROM	AREA	NZ	NZ\ROM	HA	H	UK	LK	K
ROOM	FE	Spine8	L3L4	10	0.9793	1.1806	1.1667	1.1912	1.2055	1.2067	1.0373	1.0230	1.0305
ROOM	FE	Spine8	L3L4	12	0.9713	1.1864	1.1698	1.2042	1.2213	1.2255	1.0234	1.0503	1.0362
ROOM	FE	Spine8	L3L4	14	0.9703	1.2514	1.2486	1.2868	1.2897	1.2929	1.0109	1.0366	1.0232
BODY	FE	Spine8	L5S1	0.25	1.1855	1.2453	1.2230	1.0312	1.0505	1.0695	0.8689	0.8783	0.8737
BODY	FE	Spine8	L5S1	0.5	1.1031	1.1338	1.1149	1.0103	1.0278	1.0446	0.9350	0.9319	0.9335
BODY	FE	Spine8	L5S1	0.5	1.1397	1.1952	1.1808	1.0356	1.0487	1.0642	0.8945	0.9058	0.9002
BODY	FE	Spine8	L5S1	2	0.8840	0.8611	0.8758	0.9903	0.9741	0.9608	1.0914	1.0983	1.0949
BODY	FE	Spine8	L5S1	2	1.0011	0.9983	1.0075	1.0060	0.9972	0.9911	0.9777	0.9877	0.9828
BODY	FE	Spine8	L5S1	4	0.8115	0.8358	0.8766	1.0799	1.0301	0.9947	1.1347	1.1260	1.1303
BODY	FE	Spine8	L5S1	4	0.9504	0.9909	0.9963	1.0478	1.0426	1.0392	1.0386	1.0412	1.0399
BODY	FE	Spine8	L5S1	6	0.7985	0.8476	0.8907	1.1150	1.0615	1.0232	1.1598	1.1280	1.1436
BODY	FE	Spine8	L5S1	6	0.8851	0.9780	0.9969	1.1259	1.1050	1.0873	1.0847	1.0925	1.0887
BODY	FE	Spine8	L5S1	8	0.7940	0.8923	0.9197	1.1578	1.1238	1.0963	1.1847	1.1925	1.1887
BODY	FE	Spine8	L5S1	8	0.8569	0.9502	0.9621	1.1223	1.1089	1.0954	1.1433	1.1245	1.1338
BODY	FE	Spine8	L5S1	10	0.7778	0.9367	0.9721	1.2493	1.2044	1.1702	1.1931	1.2058	1.1995
BODY	FE	Spine8	L5S1	10	0.8134	0.9137	0.9569	1.1759	1.1233	1.0847	1.1312	1.1267	1.1289
BODY	FE	Spine8	L5S1	12	0.7857	0.9205	0.9489	1.2072	1.1716	1.1444	1.1953	1.2089	1.2022
BODY	FE	Spine8	L5S1	12	0.8133	0.9346	0.9601	1.1800	1.1492	1.1248	1.1736	1.1564	1.1649
BODY	FE	Spine8	L5S1	14	0.7981	0.9419	0.9732	1.2188	1.1802	1.1497	1.1734	1.1819	1.1777

APPENDIX D. STATISTICAL CODE FOR DATA ANALYSIS

D.1. Temperature and Compressive Follower-load Tests

```
/*===========================================================================
Name: Dean Keith Stolworthy
Company: Brigham Young University (BYU)
Department: Mechanical Engineering
Laboratory: BYU Applied Biomechanics Engineering Laboratory (BABEL)

File: /TL_v12.sas

Summary: This program reads in the spine data, including test specimen,
test conditions, and the  Dual-inflection Point (DIP) Blotzmann parameters
(ROM, Ua1, Um1, Ua2, Um2, La1, Lm1, La2, Lm2), which were determined
previously using a least-squares method (Excel Solver).  Further calculations
are performed to determine metrics (Neutral Zone, Area, stiffness,
hysteresis)
that are commonly used to quantitatively describe the torque-rotation (TR)
response.
Each DIP-Boltzmann parameter and TR-metric is normalized with the
the same parameter (or metric) that was obtained at different testing
temperature (Temp-Norm) or loading condition (Load-Norm), but within the same
Spine+Segment (FSU) and loading direction (DIR).  Normalization is expected
to
negate intra-specimen (FSU+DIR) variability while magnifying interspecimen
(Temp+Load)variability.
A multi-variable analysis of variance (MANOVA) was performed on the raw and
normalized datasets to determine which of the test conditions
(Temperature and/or Load) affects the TR response, specified as p<0.05
(w/ alpha=0.05). An effort is made to predict the TR metrics at altered
testing conditions, which is accompanied by a Bland-Altman analysis comparing
the predicted to the actual TR metrics.
===========================================================================*/
/*===========================================================================
Revisions:
(1) TL_v1.sas 7/25/2011
(2) TL_v2.sas 7/27/2011
(3) TL_v3.sas 8/5/2011
(4) TL_v4.sas 8/12/2011
(5) TL_v5.sas 8/17/2011
(6) TL_v6.sas 8/22/2011
(7) TL_v7.sas 8/30/2011
(8) TL_v8.sas 8/31/2011
(9) TL_v9.sas 9/9/2011
(10) TL_v10.sas 9/13/2011
```

```
(11) TL_v11.sas 10/10/2011
(12) TL_v12.sas 10/11/2011
*/

goptions reset=all; /*Clear format settings*/
title1 "Temperature and Compressive Load";
*ods listing;           /*turn on output delivery system (ODS)*/
ods listing close;      /*turn off ODS*/

%let Path = C:\Users\Dean\Documents\1_School\Research\Thesis\4_DATA
Spreadsheets\PaperA_TempLoad\STAT\TL_v12;
%let Tmax = 7.5; /*Nm*/
%let Tmin = -7.5; /*Nm*/
%let Tstep = 0.001;
%let SS = 0.05; /*Statistical Significance p-value, alpha<0.05*/
%let NZpercent = 0.90; /*range of NZ to use when calculating H and K*/

/*============Import Data============*/
      /* Import TL raw data from datafile */
      proc import out = WORK.TL
            datafile =
'C:\Users\Dean\Documents\1_School\Research\Thesis\4_DATA
Spreadsheets\PaperA_TempLoad\STAT\TEMP_v6.xlsm'
            dbms = EXCEL replace;
            range = "TempLoad_Summary$";
            getnames = YES;
            mixed = NO;
            scantext = YES;
            usedate = YES;
            scantime = YES;
      run;

/*============Create and filter datasets for analysis============*/

      data TL(drop=UAREA LAREA);
            set TL(keep=Dir Spine Segment Load Temp UA UB Ua1 Um1 Ua2 Um2 LA
LB La1 Lm1 La2 Lm2 ROM AREA);
            if Ua1=. or Ua2=. or Um1=. or Um2=. or La1=. or La2=. or Lm1=. or
Lm2=. or UA=. or UB=. or LA=. or LB=. then delete;
            if Ua1=0.3 or Ua2=0.3 or Um1=0.3 or Um2=0.3 or La1=0.3 or La2=0.3
or Lm1=0.3 or Lm2=0.3 then delete;
            if ROM<=0 or AREA<=0 or ROM=. or AREA=. then delete;
            if segment='L4L5' then segment='L3L4'; /*L4L5 treated same as
L3L4*/
            if segment='L2L3' then segment='L1L2'; /*L2L3 treated same as
L1L2*/
            if spine='C070369' and segment='L1L2' then FSU='FSU1a';
            if spine='C070369' and segment='L3L4' then FSU='FSU1b';
            if spine='C070369' and segment='L5S1' then FSU='FSU1c';
            if spine='C090519' and segment='L1L2' then FSU='FSU2a';
            if spine='C090519' and segment='L3L4' then FSU='FSU2b';
            if spine='C090519' and segment='L5S1' then FSU='FSU2c';
            if spine='C091292' and segment='L1L2' then FSU='FSU3a';
            if spine='C091292' and segment='L3L4' then delete
/*FSU='FSU3b'*/;
            if spine='C091292' and segment='L5S1' then FSU='FSU3c';
            if spine='C091351' and segment='L1L2' then FSU='FSU4a';
```

```
            if spine='C091351' and segment='L3L4' then FSU='FSU4b';
            if spine='C091351' and segment='L5S1' then FSU='FSU4c';
            if spine='C100115' and segment='L1L2' then FSU='FSU5a';
            if spine='C100115' and segment='L3L4' then FSU='FSU5b';
            if spine='C100115' and segment='L5S1' then FSU='FSU5c';
            if spine='S090647' and segment='L1L2' then FSU='FSU6a';
            if spine='S090647' and segment='L3L4' then FSU='FSU6b';
            if spine='S090647' and segment='L5S1' then FSU='FSU6c';
            if spine='S091199' and segment='L1L2' then FSU='FSU7a';
            if spine='S091199' and segment='L3L4' then FSU='FSU7b';
            if spine='S091199' and segment='L5S1' then FSU='FSU7c';
            if spine='S100589' and segment='L1L2' then FSU='FSU8a';
            if spine='S100589' and segment='L3L4' then FSU='FSU8b';
            if spine='S100589' and segment='L5S1' then FSU='FSU8c';
            if spine='C070369' then Spine='Spine1';
            if spine='C090519' then Spine='Spine2';
            if spine='C091292' then Spine='Spine3';
            if spine='C091351' then Spine='Spine4';
            if spine='C100115' then Spine='Spine5';
            if spine='S090647' then Spine='Spine6';
            if spine='S091199' then Spine='Spine7';
            if spine='S100589' then Spine='Spine8';
            ROM = mean(abs(UB-UA),abs(LB-LA));
            UAREA = UA*(&Tmax-&Tmin) - UA/Ua1*log((1+exp(Ua1*(&Tmax-
Um1)))/(1+exp(Ua1*(&Tmin-Um1)))) + UB/Ua2*log((1+exp(Ua2*(&Tmax-
Um2)))/(1+exp(Ua2*(&Tmin-Um2))));
            LAREA = LA*(&Tmax-&Tmin) - LA/La1*log((1+exp(La1*(&Tmax-
Lm1)))/(1+exp(La1*(&Tmin-Lm1)))) + LB/La2*log((1+exp(La2*(&Tmax-
Lm2)))/(1+exp(La2*(&Tmin-Lm2))));
            AREA = UAREA - LAREA;
            HA = AREA/ROM;    /*HysteresisArea calculates the average spread
per degree of the ROM*/
      run;

%macro makeDATA(raw=, rawNZkh=, rawNZ=, rawNL=, rawNT=, rawcl=, rawct=);
      proc sort data=&raw;
            by Dir Temp FSU Load ROM;
      run;

      /*Discrete rotation calculation of upper and lower DIP-Boltzmann
curves*/
      data &rawNZkh;
            set &raw;
            do m = &Tmin to &Tmax by &Tstep;
                  Utheta = UA/(1+exp(Ua1*(m-Um1))) - UB/(1+exp(Ua2*(m-Um2)))
+ UB; /*thetaUP*/
                  Ltheta = LA/(1+exp(La1*(m-Lm1))) - LB/(1+exp(La2*(m-Lm2)))
+ LB; /*thetaLOW*/
                  Dtheta = Utheta - Ltheta;
                  output;
            end;
      run;

      /*Determine NZ as the maximum rotation difference between upper and
lower curves*/
      proc means data=&rawNZkh (keep=Dir Temp FSU Load ROM Dtheta) max
noprint;
```

```
		var Dtheta;
		by Dir Temp FSU Load ROM;
		output out=&rawNZ(drop=_TYPE_ _FREQ_)
			max=NZ;
	run;

	/*Attach NZ to NZkh dataset */
	/*Set limit for calculating K and H, based on NZ*/
	/*Calculate derivative of upper and lower curves within a% of NZ*/
	data &rawNZkh (keep=Dir Temp FSU Load ROM NZ mUP mLOW UK LK);
		merge &rawNZkh &rawNZ;
		by Dir Temp FSU Load ROM;
		/*To get NZ flexibility coefficient, determine the slope of the
torque-rotation curve at rotation=0*/
		if Utheta>-&NZpercent*NZ/2 and Utheta<&NZpercent*NZ/2 then Uf = -
UA*Ua1*exp(Ua1*(m-Um1))/(1+exp(Ua1*(m-Um1)))**2 + UB*Ua2*exp(Ua2*(m-
Um2))/(1+exp(Ua2*(m-Um2)))**2;
			UK=1/Uf;	/* [Stiffness] = 1/[Flexibility] */
		if Ltheta>-&NZpercent*NZ/2 and Ltheta<&NZpercent*NZ/2 then Lf = -
LA*La1*exp(La1*(m-Lm1))/(1+exp(La1*(m-Lm1)))**2 + LB*La2*exp(La2*(m-
Lm2))/(1+exp(La2*(m-Lm2)))**2;
			LK=1/Lf;	/* [Stiffness] = 1/[Flexibility] */
		if Utheta>-&NZpercent*NZ/2 and Utheta<&NZpercent*NZ/2 then mUP =
m;
		if Ltheta>-&NZpercent*NZ/2 and Ltheta<&NZpercent*NZ/2 then mLOW =
m;
	run;

	/*Select UK, LK, mUP, and mLOW for each test subject (FSU+TEMP+DIR)*/
	proc means data=&rawNZkh mean noprint;
		var UK LK mUP mLOW;
		by Dir Temp FSU Load ROM NZ; /*want UK, LK for each obs*/
		output out=&rawNZkh(drop=_TYPE_ _FREQ_)
			mean=UK LK mUP mLOW;
	run;

	/*Attach NZ UK LK to raw dataset*/
	data &raw(drop=mLOW mUP);
		merge &raw &rawNZkh;
		by Dir Temp FSU Load ROM;
		K=mean(UK,LK); /*average stiffness coefficient of subject*/
		H=mLOW-mUP; /*hysteresis: focuses on the mid-portion of the
torque-rotation curve*/
		NZROMr=NZ/ROM;	/*NZ-to-ROM ratio*/
		if K>15 or K<-.5 then delete;
		if FSU='FSU8c' and K>7 then delete;
	run;

	/*Sort Raw TL data for normalizing*/
	proc sort data=&raw;
		by Dir FSU Temp Load;
	run;

	/* Create normalizing variables for each Dir*Temp*FSU*/
		proc means data=&raw mean noprint;
			var Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM NZ NZromR AREA HA H
UK LK K;
```

```
                  by Dir FSU Temp; /*Group*/
                  where Load='L';   /*Control Variable @ Load =
Loaded*/
                  output out=&rawcL(drop=_TYPE_ _FREQ_)
                        mean=Ua1c Um1c Ua2c Um2c La1c Lm1c La2c Lm2c ROMc NZc
NZromRc AREAc HAc Hc UKc LKc Kc;
            run;

      /*Normalize raw data: grouping=FSU(Spine+Segment), Temp, Dir */
      data &rawNL(keep=Dir Spine Segment FSU Temp Load Ua1 Um1 Ua2 Um2 La1
Lm1 La2 Lm2 ROM NZ NZromR AREA HA H UK LK K);
            merge &raw &rawcL;
            by Dir FSU Temp;
            Ua1 = Ua1/Ua1c;
            Um1 = Um1/Um1c;
            Ua2 = Ua2/Ua2c;
            Um2 = Um2/Um2c;
            La1 = La1/La1c;
            Lm1 = Lm1/Lm1c;
            La2 = La2/La2c;
            Lm2 = Lm2/Lm2c;
            ROM = ROM/ROMc;
            NZ = NZ/NZc;
            NZromR = NZromR/NZromRc;
            AREA = AREA/AREAc;
            HA = HA/HAc;
            H = H/Hc;
            UK = UK/UKc;
            LK = LK/LKc;
            K = K/Kc;
            if Ua1>6 or Um1>6 or Ua2>6 or Um2>6 or La1>6 or Lm1>6 or La2>6 or
Lm2>6 then delete;
      run;

      /*Sort Raw TL data for normalizing*/
      proc sort data=&raw;
            by Dir FSU Load Temp;
      run;

      /* Create normalizing variables for each Dir*Load*FSU*/
            proc means data=&raw mean noprint;
                  var Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM NZ NZromR AREA HA H
UK LK K;
                  by Dir FSU Load; /*Group*/
                  where Temp='BODY';      /*Control Variable @ Body Temp*/
                  output out=&rawcT(drop=_TYPE_ _FREQ_)
                        mean=Ua1c Um1c Ua2c Um2c La1c Lm1c La2c Lm2c ROMc NZc
NZromRc AREAc HAc Hc UKc LKc Kc;
            run;

      /*Normalize raw data: grouping=FSU(Spine+Segment), Temp, Dir */
      data &rawNT(keep=Dir Spine Segment FSU Load Temp Ua1 Um1 Ua2 Um2 La1
Lm1 La2 Lm2 ROM NZ NZromR AREA HA H UK LK K);
            merge &raw &rawcT;
            by Dir FSU Load;
            Ua1 = Ua1/Ua1c;
            Um1 = Um1/Um1c;
```

```
            Ua2 = Ua2/Ua2c;
            Um2 = Um2/Um2c;
            La1 = La1/La1c;
            Lm1 = Lm1/Lm1c;
            La2 = La2/La2c;
            Lm2 = Lm2/Lm2c;
            ROM = ROM/ROMc;
            NZ = NZ/NZc;
            NZromR = NZromR/NZromRc;
            AREA = AREA/AREAc;
            HA = HA/HAc;
            H = H/Hc;
            UK = UK/UKc;
            LK = LK/LKc;
            K = K/Kc;
            if Ua1>6 or Um1>6 or Ua2>6 or Um2>6 or La1>6 or Lm1>6 or La2>6 or
Lm2>6 then delete;
      run;

      /*delete temporary dataset*/
      proc datasets library=work;
            delete &rawNZkh &rawNZ &rawcL &rawcT;
      run;quit;

      data &raw; set &raw;
            if UK=. or LK=. or ROM=. or NZ=. then delete;
      run;

      data &rawNL; set &rawNL;
            if UK=. or LK=. or ROM=. or NZ=. then delete;
      run;

      data &rawNT; set &rawNT;
            if UK=. or LK=. or ROM=. or NZ=. then delete;
      run;
%mend makeDATA;
%makeDATA(raw=TL, rawNZkh=TLnzKH, rawNZ=TLnz, rawNL=TLnL, rawNT=TLnT,
rawcL=TLcL, rawcT=TLcT);

/*=================Report Analysis Datasets, raw and
normalized============*/
options orientation=portrait; /*page formatting*/ /*page formatting*/
/*options 1s=78 pageno=1 */
ods pdf file="&Path\DATA.pdf";
ods rtf file="&Path\DATA.rtf";

%macro rawREPORT(FIN=, titDIP=, titR=, FINset=);
      /* Report DIP-Boltzmann Data */
      proc report data=&FIN nowd headline headskip;
            column Temp Dir Spine Segment Load Ua1 Um1 Ua2 Um2 La1 Lm1 La2
Lm2 ROM;
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Load / center;
            define Ua1 / center format=6.4;
            define Um1 / center format=6.4;
```

```
            define Ua2 / center format=6.4;
            define Um2 / center format=6.4;
            define La1 / center format=6.4;
            define Lm1 / center format=6.4;
            define La2 / center format=6.4;
            define Lm2 / center format=6.4;
            define ROM / center format=6.4;
            title2 "&FIN &titDIP";
      run;

      /*Report Calculated Flexibility Data*/
      proc report data=&FIN nowd headline headskip;
            column Temp Dir Spine Segment Load ROM AREA NZ NZROMr HA H UK LK
K;
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Load / center;
            define ROM / center format=6.4;
            define AREA / center format=6.4;
            define HA / center format=6.4;
            define H / center format=6.4;
            define NZ / center format=6.4;
            define NZROMr / center 'NZ\ROM' format=6.4;
            define UK / center format=6.4;
            define LK / center format=6.4;
            define K / center format=6.4;
            title2 "&titR";
      run;

%mend rawReport;
%rawREPORT(FIN=TL , titDIP=DIP-Boltzmann Data, titR=TL Flexibility Raw Data);

%macro dataREPORT(FIN=, titDIP=, titR=, FINset=, VAR=, VARfilt=);
      /* Report DIP-Boltzmann Data */
      proc report data=&FIN nowd headline headskip;
            column Temp Dir Spine Segment Load Ua1 Um1 Ua2 Um2 La1 Lm1 La2
Lm2 ROM;
            where &VAR ne "&VARFILT";
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Load / center;
            define Ua1 / center format=6.4;
            define Um1 / center format=6.4;
            define Ua2 / center format=6.4;
            define Um2 / center format=6.4;
            define La1 / center format=6.4;
            define Lm1 / center format=6.4;
            define La2 / center format=6.4;
            define Lm2 / center format=6.4;
            define ROM / center format=6.4;
            title2 "&FIN &titDIP";
      run;

      /*Report Calculated Flexibility Data*/
      proc report data=&FIN nowd headline headskip;
```

```
            column Temp Dir Spine Segment Load ROM AREA NZ NZROMr HA H
UK LK K;
            where &VAR ne "&VARFILT";
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Load / center;
            define ROM / center format=6.4;
            define AREA / center format=6.4;
            define HA / center format=6.4;
            define H / center format=6.4;
            define NZ / center format=6.4;
            define NZROMr / center 'NZ\ROM' format=6.4;
            define UK / center format=6.4;
            define LK / center format=6.4;
            define K / center format=6.4;
            title2 "&titR";
            footnote "Normalized observations are identity for &VAR =
&VARfilt";
      run;

%mend dataReport;
%dataREPORT(FIN=TLnL, titDIP=DIP-Boltzmann Data, titR=TLloadNorm Flexibility
Data (noLoad/Load), VAR=Load, VARfilt=L);
%dataREPORT(FIN=TLnT, titDIP=DIP-Boltzmann Data, titR=TLtempNorm Flexibility
Data (Room/Body), VAR=Temp, VARfilt=BODY);

      /* TL data seperated by loading direction*/
      data tlAR; set TL;      if Dir='AR'; run;
      data tlFE; set TL;      if Dir='FE'; run;
      data tlLB; set TL;      if Dir='LB'; run;
      data tlARnL; set TLnL;  if Dir='AR'; run;
      data tlFEnL; set TLnL;  if Dir='FE'; run;
      data tlLBnL; set TLnL;  if Dir='LB'; run;
      data tlARnT; set TLnT;  if Dir='AR'; run;
      data tlFEnT; set TLnT;  if Dir='FE'; run;
      data tlLBnT; set TLnT;  if Dir='LB'; run;

/*Box-Plots of rawData/Grouped by Dir*/
goptions reset=footnote symbol;
ods listing close;

* LEGEND;
legend1
      label=(f="Albany AMT" h=2)
      value=(font="Albany AMT" h=3);
* XAXIS - HORIZONTAL - AVERAGE;
axis1 /*length=6.5 in width=1*/
      label=(f="Albany AMT" h=3)
      value=(font="Albany AMT" h=3);
* YAXIS - Vertical - Difference;
axis2 /*length=6.5 in width=1*/
      label=(f="Albany AMT" h=3)
      value=(font="Albany AMT" h=3);

symbol1 v=X i=none cv=red ci=red co=red;
symbol2 v=circle i=none cv=blue ci=blue co=blue;
```

```
%macro boxMACRO(dataset=, var=, t2=);
      proc sort data=&dataset;
            by Dir Load Temp;
      run;

      title2 "&t2";

      proc boxplot data=&dataset;
            by Dir;
            plot &var*Load/ haxis=axis1 vaxis=axis2 symbollegend=legend1;
                  label       &var = "&t2" Temp='Temperature';
      run;

      proc boxplot data=&dataset;
            by Dir;
            plot &var*Temp=Load/ haxis=axis1 vaxis=axis2
symbollegend=legend1;
                  label       &var = "&t2" Temp='Temperature';
      run;

      proc sort data=&dataset;
            by Dir Temp Load;
      run;

      proc boxplot data=&dataset;
            by Dir;
            plot &var*Temp/ haxis=axis1 vaxis=axis2 symbollegend=legend1;
                  label       &var = "&t2" Temp='Temperature';
      run;

      proc boxplot data=&dataset;
            by Dir;
            plot &var*Load=Temp/ haxis=axis1 vaxis=axis2
symbollegend=legend1;
                  label       &var = "&t2" Temp='Temperature';
      run;

%mend;
%boxMACRO(dataset=TL, var=ROM, t2=Range of Motion);
%boxMACRO(dataset=TL, var=AREA, t2=Area);
%boxMACRO(dataset=TL, var=NZ, t2=Neutral Zone);
%boxMACRO(dataset=TL, var=NZromR, t2=NZ-ROM-ratio);
%boxMACRO(dataset=TL, var=HA, t2=Hysteresis Area);
%boxMACRO(dataset=TL, var=H, t2=Hysteresis);
%boxMACRO(dataset=TL, var=UK, t2=Upper Stiffness);
%boxMACRO(dataset=TL, var=LK, t2=Lower Stiffness);
%boxMACRO(dataset=TL, var=K, t2=Stiffness);
%boxMACRO(dataset=TL, var=Ua1, t2=alpha1UPPER);
%boxMACRO(dataset=TL, var=Um1, t2=m1UPPER);
%boxMACRO(dataset=TL, var=Ua2, t2=alpha2UPPER);
%boxMACRO(dataset=TL, var=Um2, t2=m2UPPER);
%boxMACRO(dataset=TL, var=La1, t2=alpha1LOWER);
%boxMACRO(dataset=TL, var=Lm1, t2=M1LOWER);
%boxMACRO(dataset=TL, var=La2, t2=alpha2LOWER);
%boxMACRO(dataset=TL, var=Lm2, t2=m2LOWER);
```

```
ods rtf close;
ods pdf close;

ods listing close;      /*Turn off ODS listing*/
/*================Perform Mixed-Models Analysis on DIP-Boltzmann and
Flexbility Data==================*/
%macro MixAn(tlDAT=, tlarDAT=, tlfeDAT=, tllbDAT=, dvar=, tl3=, tlAR3=,
tlFE3=, tlLB3=, tlLS=, tlarLS=, tlfeLS=, tllbLS=);
/* Perform MANOVA for (model=&dvar) variables of the selected datasets*/

      /* MANOVA of TLxx */
      proc mixed data=&tlDAT;
          class Load Temp Spine Segment FSU Dir;
          model &dvar = Load Temp FSU Load*Temp*Dir Dir;
            random Load/subject=Dir*FSU*Temp;
            lsmeans Load*Temp*Dir/pdiff adjust=tukey;
          title2 "MANOVA for TL DIP-Boltzmann &dvar";
            ods output Tests3 = &tl3(keep=ProbF) LSmeans = &tlLS(keep=Dir
Temp Load Estimate StdErr);
      run;

      /* MANOVA of tlAR */
      proc mixed data=&tlarDAT;
          class Load Temp Spine Segment FSU Dir;
          model &dvar = Load Temp FSU Load*Temp*Dir Dir;
            random Load/subject=FSU*Temp;
            lsmeans Load*Temp*Dir/pdiff adjust=tukey;
          title2 "MANOVA for tlAR DIP-Boltzmann &dvar";
            ods output Tests3 = &tlAR3(keep=ProbF) LSmeans = &tlarLS(keep=Dir
Temp Load Estimate StdErr);
      run;

      /* MANOVA of tlFE */
      proc mixed data=&tlfeDAT;
          class Load Temp Spine Segment FSU Dir;
          model &dvar = Load Temp FSU Load*Temp*Dir Dir;
            random Load/subject=FSU*Temp;
            lsmeans Load*Temp*Dir/pdiff adjust=tukey;
          title2 "MANOVA for tlFE DIP-Boltzmann &dvar";
            ods output Tests3 = &tlFE3(keep=ProbF) LSmeans = &tlfeLS(keep=Dir
Temp Load Estimate StdErr);
      run;

      /* MANOVA of tlLB */
      proc mixed data=&tllbDAT;
          class Load Temp Spine Segment FSU Dir;
          model &dvar = Load Temp FSU Load*Temp*Dir Dir;
          random Load/subject=FSU*Temp;
            lsmeans Load*Temp*Dir/pdiff adjust=tukey;
          title2 "MANOVA for tlLB DIP-Boltzmann &dvar";
            ods output Tests3 = &tlLB3(keep=ProbF) LSmeans = &tllbLS(keep=Dir
Temp Load Estimate StdErr);
      run;
%mend MixAn;
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=Ua1,
tl3=Ua1tl3, tlAR3=Ua1tlAR3, tlFE3=Ua1tlFE3, tlLB3=Ua1tlLB3, tlLS=Ua1tlLS,
tlarLS=Ua1tlarLS, tlfeLS=Ua1tlfeLS, tllbLS=Ua1tllbLS);
```

```
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=Um1,
tl3=Um1tl3, tlAR3=Um1tlAR3, tlFE3=Um1tlFE3, tlLB3=Um1tlLB3,
tlLS=Um1tlLS, tlarLS=Um1tlarLS, tlfeLS=Um1tlfeLS, tllbLS=Um1tllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=Ua2,
tl3=Ua2tl3, tlAR3=Ua2tlAR3, tlFE3=Ua2tlFE3, tlLB3=Ua2tlLB3, tlLS=Ua2tlLS,
tlarLS=Ua2tlarLS, tlfeLS=Ua2tlfeLS, tllbLS=Ua2tllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=Um2,
tl3=Um2tl3, tlAR3=Um2tlAR3, tlFE3=Um2tlFE3, tlLB3=Um2tlLB3, tlLS=Um2tlLS,
tlarLS=Um2tlarLS, tlfeLS=Um2tlfeLS, tllbLS=Um2tllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=La1,
tl3=La1tl3, tlAR3=La1tlAR3, tlFE3=La1tlFE3, tlLB3=La1tlLB3, tlLS=La1tlLS,
tlarLS=La1tlarLS, tlfeLS=La1tlfeLS, tllbLS=La1tllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=Lm1,
tl3=Lm1tl3, tlAR3=Lm1tlAR3, tlFE3=Lm1tlFE3, tlLB3=Lm1tlLB3, tlLS=Lm1tlLS,
tlarLS=Lm1tlarLS, tlfeLS=Lm1tlfeLS, tllbLS=Lm1tllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=La2,
tl3=La2tl3, tlAR3=La2tlAR3, tlFE3=La2tlFE3, tlLB3=La2tlLB3, tlLS=La2tlLS,
tlarLS=La2tlarLS, tlfeLS=La2tlfeLS, tllbLS=La2tllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=Lm2,
tl3=Lm2tl3, tlAR3=Lm2tlAR3, tlFE3=Lm2tlFE3, tlLB3=Lm2tlLB3, tlLS=Lm2tlLS,
tlarLS=Lm2tlarLS, tlfeLS=Lm2tlfeLS, tllbLS=Lm2tllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=ROM,
tl3=ROMtl3, tlAR3=ROMtlAR3, tlFE3=ROMtlFE3, tlLB3=ROMtlLB3, tlLS=ROMtlLS,
tlarLS=ROMtlarLS, tlfeLS=ROMtlfeLS, tllbLS=ROMtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=Area,
tl3=AREAtl3, tlAR3=AREAtlAR3, tlFE3=AREAtlFE3, tlLB3=AREAtlLB3,
tlLS=AREAtlLS, tlarLS=AREAtlarLS, tlfeLS=AREAtlfeLS, tllbLS=AREAtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=NZ,
tl3=NZtl3, tlAR3=NZtlAR3, tlFE3=NZtlFE3, tlLB3=NZtlLB3, tlLS=NZtlLS,
tlarLS=NZtlarLS, tlfeLS=NZtlfeLS, tllbLS=NZtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=NZromR,
tl3=NZromRtl3, tlAR3=NZromRtlAR3, tlFE3=NZromRtlFE3, tlLB3=NZromRtlLB3,
tlLS=NZromRtlLS, tlarLS=NZromRtlarLS, tlfeLS=NZromRtlfeLS,
tllbLS=NZromRtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=HA,
tl3=HAtl3, tlAR3=HAtlAR3, tlFE3=HAtlFE3, tlLB3=HAtlLB3, tlLS=HAtlLS,
tlarLS=HAtlarLS, tlfeLS=HAtlfeLS, tllbLS=HAtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=H, tl3=Htl3,
tlAR3=HtlAR3, tlFE3=HtlFE3, tlLB3=HtlLB3, tlLS=HtlLS, tlarLS=HtlarLS,
tlfeLS=HtlfeLS, tllbLS=HtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=UK,
tl3=UKtl3, tlAR3=UKtlAR3, tlFE3=UKtlFE3, tlLB3=UKtlLB3, tlLS=UKtlLS,
tlarLS=UKtlarLS, tlfeLS=UKtlfeLS, tllbLS=UKtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=LK,
tl3=LKtl3, tlAR3=LKtlAR3, tlFE3=LKtlFE3, tlLB3=LKtlLB3, tlLS=LKtlLS,
tlarLS=LKtlarLS, tlfeLS=LKtlfeLS, tllbLS=LKtllbLS);
%MixAn(tlDAT=tl, tlarDAT=tlAR, tlfeDAT=tlFE, tllbDAT=tlLB, dvar=K, tl3=Ktl3,
tlAR3=KtlAR3, tlFE3=KtlFE3, tlLB3=KtlLB3, tlLS=KtlLS, tlarLS=KtlarLS,
tlfeLS=KtlfeLS, tllbLS=KtllbLS);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=Ua1,
tl3=Ua1tl3nL, tlAR3=Ua1tlAR3nL, tlFE3=Ua1tlFE3nL, tlLB3=Ua1tlLB3nL,
tlLS=Ua1tlLSnL, tlarLS=Ua1tlarLSnL, tlfeLS=Ua1tlfeLSnL, tllbLS=Ua1tllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=Um1,
tl3=Um1tl3nL, tlAR3=Um1tlAR3nL, tlFE3=Um1tlFE3nL, tlLB3=Um1tlLB3nL,
tlLS=Um1tlLSnL, tlarLS=Um1tlarLSnL, tlfeLS=Um1tlfeLSnL, tllbLS=Um1tllbLSnL);
```

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%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL,
dvar=Ua2, tl3=Ua2tl3nL, tlAR3=Ua2tlAR3nL, tlFE3=Ua2tlFE3nL,
tlLB3=Ua2tlLB3nL, tlLS=Ua2tlLSnL, tlarLS=Ua2tlarLSnL,
tlfeLS=Ua2tlfeLSnL, tllbLS=Ua2tllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=Um2,
tl3=Um2tl3nL, tlAR3=Um2tlAR3nL, tlFE3=Um2tlFE3nL, tlLB3=Um2tlLB3nL,
tlLS=Um2tlLSnL, tlarLS=Um2tlarLSnL, tlfeLS=Um2tlfeLSnL, tllbLS=Um2tllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=La1,
tl3=La1tl3nL, tlAR3=La1tlAR3nL, tlFE3=La1tlFE3nL, tlLB3=La1tlLB3nL,
tlLS=La1tlLSnL, tlarLS=La1tlarLSnL, tlfeLS=La1tlfeLSnL, tllbLS=La1tllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=Lm1,
tl3=Lm1tl3nL, tlAR3=Lm1tlAR3nL, tlFE3=Lm1tlFE3nL, tlLB3=Lm1tlLB3nL,
tlLS=Lm1tlLSnL, tlarLS=Lm1tlarLSnL, tlfeLS=Lm1tlfeLSnL, tllbLS=Lm1tllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=La2,
tl3=La2tl3nL, tlAR3=La2tlAR3nL, tlFE3=La2tlFE3nL, tlLB3=La2tlLB3nL,
tlLS=La2tlLSnL, tlarLS=La2tlarLSnL, tlfeLS=La2tlfeLSnL, tllbLS=La2tllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=Lm2,
tl3=Lm2tl3nL, tlAR3=Lm2tlAR3nL, tlFE3=Lm2tlFE3nL, tlLB3=Lm2tlLB3nL,
tlLS=Lm2tlLSnL, tlarLS=Lm2tlarLSnL, tlfeLS=Lm2tlfeLSnL, tllbLS=Lm2tllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=ROM,
tl3=ROMtl3nL, tlAR3=ROMtlAR3nL, tlFE3=ROMtlFE3nL, tlLB3=ROMtlLB3nL,
tlLS=ROMtlLSnL, tlarLS=ROMtlarLSnL, tlfeLS=ROMtlfeLSnL, tllbLS=ROMtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=Area,
tl3=AREAtl3nL, tlAR3=AREAtlAR3nL, tlFE3=AREAtlFE3nL, tlLB3=AREAtlLB3nL,
tlLS=AREAtlLSnL, tlarLS=AREAtlarLSnL, tlfeLS=AREAtlfeLSnL,
tllbLS=AREAtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=NZ,
tl3=NZtl3nL, tlAR3=NZtlAR3nL, tlFE3=NZtlFE3nL, tlLB3=NZtlLB3nL,
tlLS=NZtlLSnL, tlarLS=NZtlarLSnL, tlfeLS=NZtlfeLSnL, tllbLS=NZtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL,
dvar=NZromR, tl3=NZromRtl3nL, tlAR3=NZromRtlAR3nL, tlFE3=NZromRtlFE3nL,
tlLB3=NZromRtlLB3nL, tlLS=NZromRtlLSnL, tlarLS=NZromRtlarLSnL,
tlfeLS=NZromRtlfeLSnL, tllbLS=NZromRtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=HA,
tl3=HAtl3nL, tlAR3=HAtlAR3nL, tlFE3=HAtlFE3nL, tlLB3=HAtlLB3nL,
tlLS=HAtlLSnL, tlarLS=HAtlarLSnL, tlfeLS=HAtlfeLSnL, tllbLS=HAtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=H,
tl3=Htl3nL, tlAR3=HtlAR3nL, tlFE3=HtlFE3nL, tlLB3=HtlLB3nL, tlLS=HtlLSnL,
tlarLS=HtlarLSnL, tlfeLS=HtlfeLSnL, tllbLS=HtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=UK,
tl3=UKtl3nL, tlAR3=UKtlAR3nL, tlFE3=UKtlFE3nL, tlLB3=UKtlLB3nL,
tlLS=UKtlLSnL, tlarLS=UKtlarLSnL, tlfeLS=UKtlfeLSnL, tllbLS=UKtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=LK,
tl3=LKtl3nL, tlAR3=LKtlAR3nL, tlFE3=LKtlFE3nL, tlLB3=LKtlLB3nL,
tlLS=LKtlLSnL, tlarLS=LKtlarLSnL, tlfeLS=LKtlfeLSnL, tllbLS=LKtllbLSnL);
%MixAn(tlDAT=TLnL, tlarDAT=tlARnL, tlfeDAT=tlFEnL, tllbDAT=tlLBnL, dvar=K,
tl3=Ktl3nL, tlAR3=KtlAR3nL, tlFE3=KtlFE3nL, tlLB3=KtlLB3nL, tlLS=KtlLSnL,
tlarLS=KtlarLSnL, tlfeLS=KtlfeLSnL, tllbLS=KtllbLSnL);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=Ua1,
tl3=Ua1tl3nT, tlAR3=Ua1tlAR3nT, tlFE3=Ua1tlFE3nT, tlLB3=Ua1tlLB3nT,
tlLS=Ua1tlLSnT, tlarLS=Ua1tlarLSnT, tlfeLS=Ua1tlfeLSnT, tllbLS=Ua1tllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=Um1,
tl3=Um1tl3nT, tlAR3=Um1tlAR3nT, tlFE3=Um1tlFE3nT, tlLB3=Um1tlLB3nT,
tlLS=Um1tlLSnT, tlarLS=Um1tlarLSnT, tlfeLS=Um1tlfeLSnT, tllbLS=Um1tllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=Ua2,
tl3=Ua2tl3nT, tlAR3=Ua2tlAR3nT, tlFE3=Ua2tlFE3nT, tlLB3=Ua2tlLB3nT,
tlLS=Ua2tlLSnT, tlarLS=Ua2tlarLSnT, tlfeLS=Ua2tlfeLSnT, tllbLS=Ua2tllbLSnT);
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%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT,
dvar=Um2, tl3=Um2tl3nT, tlAR3=Um2tlAR3nT, tlFE3=Um2tlFE3nT,
tlLB3=Um2tlLB3nT, tlLS=Um2tlLSnT, tlarLS=Um2tlarLSnT,
tlfeLS=Um2tlfeLSnT, tllbLS=Um2tllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=La1,
tl3=La1tl3nT, tlAR3=La1tlAR3nT, tlFE3=La1tlFE3nT, tlLB3=La1tlLB3nT,
tlLS=La1tlLSnT, tlarLS=La1tlarLSnT, tlfeLS=La1tlfeLSnT, tllbLS=La1tllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=Lm1,
tl3=Lm1tl3nT, tlAR3=Lm1tlAR3nT, tlFE3=Lm1tlFE3nT, tlLB3=Lm1tlLB3nT,
tlLS=Lm1tlLSnT, tlarLS=Lm1tlarLSnT, tlfeLS=Lm1tlfeLSnT, tllbLS=Lm1tllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=La2,
tl3=La2tl3nT, tlAR3=La2tlAR3nT, tlFE3=La2tlFE3nT, tlLB3=La2tlLB3nT,
tlLS=La2tlLSnT, tlarLS=La2tlarLSnT, tlfeLS=La2tlfeLSnT, tllbLS=La2tllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=Lm2,
tl3=Lm2tl3nT, tlAR3=Lm2tlAR3nT, tlFE3=Lm2tlFE3nT, tlLB3=Lm2tlLB3nT,
tlLS=Lm2tlLSnT, tlarLS=Lm2tlarLSnT, tlfeLS=Lm2tlfeLSnT, tllbLS=Lm2tllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=ROM,
tl3=ROMtl3nT, tlAR3=ROMtlAR3nT, tlFE3=ROMtlFE3nT, tlLB3=ROMtlLB3nT,
tlLS=ROMtlLSnT, tlarLS=ROMtlarLSnT, tlfeLS=ROMtlfeLSnT, tllbLS=ROMtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=Area,
tl3=AREAtl3nT, tlAR3=AREAtlAR3nT, tlFE3=AREAtlFE3nT, tlLB3=AREAtlLB3nT,
tlLS=AREAtlLSnT, tlarLS=AREAtlarLSnT, tlfeLS=AREAtlfeLSnT,
tllbLS=AREAtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=NZ,
tl3=NZtl3nT, tlAR3=NZtlAR3nT, tlFE3=NZtlFE3nT, tlLB3=NZtlLB3nT,
tlLS=NZtlLSnT, tlarLS=NZtlarLSnT, tlfeLS=NZtlfeLSnT, tllbLS=NZtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT,
dvar=NZromR, tl3=NZromRtl3nT, tlAR3=NZromRtlAR3nT, tlFE3=NZromRtlFE3nT,
tlLB3=NZromRtlLB3nT, tlLS=NZromRtlLSnT, tlarLS=NZromRtlarLSnT,
tlfeLS=NZromRtlfeLSnT, tllbLS=NZromRtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=HA,
tl3=HAtl3nT, tlAR3=HAtlAR3nT, tlFE3=HAtlFE3nT, tlLB3=HAtlLB3nT,
tlLS=HAtlLSnT, tlarLS=HAtlarLSnT, tlfeLS=HAtlfeLSnT, tllbLS=HAtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=H,
tl3=Htl3nT, tlAR3=HtlAR3nT, tlFE3=HtlFE3nT, tlLB3=HtlLB3nT, tlLS=HtlLSnT,
tlarLS=HtlarLSnT, tlfeLS=HtlfeLSnT, tllbLS=HtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=UK,
tl3=UKtl3nT, tlAR3=UKtlAR3nT, tlFE3=UKtlFE3nT, tlLB3=UKtlLB3nT,
tlLS=UKtlLSnT, tlarLS=UKtlarLSnT, tlfeLS=UKtlfeLSnT, tllbLS=UKtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=LK,
tl3=LKtl3nT, tlAR3=LKtlAR3nT, tlFE3=LKtlFE3nT, tlLB3=LKtlLB3nT,
tlLS=LKtlLSnT, tlarLS=LKtlarLSnT, tlfeLS=LKtlfeLSnT, tllbLS=LKtllbLSnT);
%MixAn(tlDAT=TLnT, tlarDAT=tlARnT, tlfeDAT=tlFEnT, tllbDAT=tlLBnT, dvar=K,
tl3=Ktl3nT, tlAR3=KtlAR3nT, tlFE3=KtlFE3nT, tlLB3=KtlLB3nT, tlLS=KtlLSnT,
tlarLS=KtlarLSnT, tlfeLS=KtlfeLSnT, tllbLS=KtllbLSnT);


/*============================================================
Begin HTML OUTPUT
============================================================*/
goptions reset=all; /*Clear all output format settings*/
title1 "Temperature and Compressive Load";      /*Set title1*/

ods html path="&Path" (url=none)    /*Initialize html output*/
      body="body.html"
      contents="toc.html"
      frame="OpenMe.html"
```

```
      style=minimal;

/*====================Summarize Data====================*/
options orientation=portrait;
ods rtf file="&Path\Results.rtf";   /*Initialize rtf output*/
ods pdf file="&Path/Summary.pdf";   /*Initialize pdf output*/

%macro Summary(dat=, AvgDAT=, StdDAT=, summTABLE=, sort1=, sort2=, sort3=);
      /* Sort filtered data for proc means*/
      proc sort data=&dat;
            by &sort1 &sort2 &sort3;
      run;

      /*Produce means and std for TL Reporting*/
      proc means data=&dat mean std noprint;
            var Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM AREA NZ NZromR HA H UK LK
K;
            by &sort1 &sort2 &sort3;
            output out=&AvgDAT
                  mean = avgUa1 avgUm1 avgUa2 avgUm2 avgLa1 avgLm1 avgLa2
avgLm2 avgROM avgAREA avgNZ avgNZromR avgHA avgH avgUK avgLK avgK;
            output out=&StdDAT
                  std = stdUa1 stdUm1 stdUa2 stdUm2 stdLa1 stdLm1 stdLa2
stdLm2 stdROM stdAREA stdNZ stdNZromR stdHA stdH stdUK stdLK stdK;
      run;

      /*Compile and format means results*/
      data &summTABLE(drop = _TYPE_ _FREQ_);
            merge &AvgDAT &StdDAT;
            asROM = cat(put(AvgROM,5.3), ' (', put(StdROM,5.3), ')');
            asAREA = cat(put(AvgAREA,5.3), ' (', put(StdAREA,5.3), ')');
            asNZ = cat(put(AvgNZ,5.3), ' (', put(StdNZ,5.3), ')');
            asNZROMr = cat(put(AvgNZROMr,5.3), ' (', put(StdNZROMr,5.3),
')');
            asHA = cat(put(AvgHA,5.3), ' (', put(StdHA,5.3), ')');
            asH = cat(put(AvgH,5.3), ' (', put(StdH,5.3), ')');
            asUK = cat(put(AvgUK,5.3), ' (', put(StdUK,5.3), ')');
            asLK = cat(put(AvgLK,5.3), ' (', put(StdLK,5.3), ')');
            asK = cat(put(AvgK,5.3), ' (', put(StdK,5.3), ')');
            asUa1 = cat(put(AvgUa1,5.3), ' (', put(StdUa1,5.3), ')');
            asUm1 = cat(put(AvgUm1,5.3), ' (', put(StdUm1,5.3), ')');
            asUa2 = cat(put(AvgUa2,5.3), ' (', put(StdUa2,5.3), ')');
            asUm2 = cat(put(AvgUm2,5.3), ' (', put(StdUm2,5.3), ')');
            asLa1 = cat(put(AvgLa1,5.3), ' (', put(StdLa1,5.3), ')');
            asLm1 = cat(put(AvgLm1,5.3), ' (', put(StdLm1,5.3), ')');
            asLa2 = cat(put(AvgLa2,5.3), ' (', put(StdLa2,5.3), ')');
            asLm2 = cat(put(AvgLm2,5.3), ' (', put(StdLm2,5.3), ')');
      run;

%mend Summary;
%Summary(dat=TL, AvgDAT=AvgTL, StdDAT=StdTL, summTABLE=TLtable, sort1=Dir,
sort2=Temp, sort3=Load);
%Summary(dat=TLnL, AvgDAT=AvgTLnL, StdDAT=StdTLnL, summTABLE=TLnlTable,
sort1=Dir, sort2=Temp, sort3=Load);
%Summary(dat=TLnT, AvgDAT=AvgTLnT, StdDAT=StdTLnT, summTABLE=TLntTable,
sort1=Dir, sort2=Load, sort3=Temp);
```

```
%macro SummRep(Table=, nlTable=, ntTable=, Title=, nlTitle=, ntTitle=);

      /*Report stiffness Data Summary*/
      proc report data=&Table headline headskip nowd;
            column DIR TEMP LOAD asROM /*asAREA*/ asNZ /*asNZromR*/ /*asHA*/
asK asH;
            define DIR/order center;
            define TEMP/order center;
            define LOAD/center;
            define asROM/'ROM' center;
            define asNZ/'NZ' center;
            define asK/'K' center;
            define asH/'H' center;
            title2 "&Title";
      run;

      /*Report load-normal stiffness Data Summary*/
      proc report data=&nlTable headline headskip nowd;
            column DIR TEMP LOAD asROM /*asAREA*/ asNZ /*asNZromR*/ /*asHA*/
asK asH;
            where LOAD='nl';
            define DIR/order center;
            define TEMP/order center;
            define LOAD/center;
            define asROM/'ROM' center;
            define asNZ/'NZ' center;
            define asK/'K' center;
            define asH/'H' center;
            title2 "&nlTitle";
            footnote "All results are identity for the loaded results";
      run;

      /*Report temp-normal stiffness Data Summary*/
      proc report data=&ntTable headline headskip nowd;
            column DIR TEMP LOAD asROM /*asAREA*/ asNZ /*asNZromR*/ /*asHA*/
asK asH;
            where Temp='ROOM';
            define DIR/order center;
            define TEMP/order center;
            define LOAD/center;
            define asROM/'ROM' center;
            define asNZ/'NZ' center;
            define asK/'K' center;
            define asH/'H' center;
            title2 "&ntTitle";
            footnote "All results are identity for the body temperature
results.";
      run;

goptions reset=all;
title1 "Temperature and Compressive Load";      /*Set title1*/

%mend SummRep;
%SummRep(Table=TLtable, nlTable=TLnlTable, ntTable=TLntTable,
Title=Continuous-Speed Loading Flexibility Summary, nlTitle=Load-Normalized
Continuous-Speed Loading Flexibility Summary, ntTitle=Temperature-Normalized
Continuous-Speed Loading Flexibility);
```

```
/* TL Frequencies */
proc freq data=TL;
      tables Spine*Segment Load*Temp FSU*Dir/nocol norow nocum;
      title2 'TL Frequencies';
run;

ods pdf close;    /*close pdf output*/

/*===============Organize P-table Probability Analysis================*/

/*Create user-defined format for p-value tables*/
proc format;
      value pFMT
      low-<.0001=" # "
      .0001-<&SS=" * "
      &SS-high="   ";
run;

      /*create row names for p-values table*/
      data Effects;
            input Effect $;
            datalines;
            Load
            Temp
            FSU
            L*T
            ;
      data EffectTL;
            input Effect $;
            datalines;
            Load
            Temp
            FSU
            L*T
            Dir
            ;

      /*Organize p-value tables*/
      %macro Ptable(TAB=, Eff=, Ua1=, Um1=, Ua2=, Um2=, La1=, Lm1=, La2=,
Lm2=, ROM=, AREA=, NZ=, NZromR=, HA=, H=, UK=, LK=, K=);
            data &TAB;
                  merge &Eff
                        &Ua1(rename=(ProbF=Ua1)) &Um1(rename=(ProbF=Um1))
&Ua2(rename=(ProbF=Ua2)) &Um2(rename=(ProbF=Um2))
                        &La1(rename=(ProbF=La1)) &Lm1(rename=(ProbF=Lm1))
&La2(rename=(ProbF=La2)) &Lm2(rename=(ProbF=Lm2))
                        &ROM(rename=(ProbF=ROM)) &AREA(rename=(ProbF=Area))
&NZ(rename=(ProbF=NZ)) &NZromR(rename=(ProbF=NZromR))
                        &HA(rename=(ProbF=HA)) &H(rename=(ProbF=H))
      &UK(rename=(ProbF=UK)) &LK(rename=(ProbF=LK)) &K(rename=(ProbF=K));
                  label ROM='ROM' Area='Area' NZ='NZ' NZromR='NZromR' HA='HA'
H='H' UK='UK' LK ='LK' K='K'
                        Ua1='Ua1' Um1='Um1' Ua2='Ua2' Um2='Um2' La1='La1'
Lm1='Lm1' La2='La2' Lm2='Lm2';
                  format Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM AREA H NZ UK LK
K pFMT.; /*apply format*/
```

```
            run;

            proc datasets library=work nolist;
                  delete &Ua1 &Um1 &Ua2 &Um2 &La1 &Lm1 &La2 &Lm2 &ROM &AREA
&NZ &NZromR &HA &H &UK &LK &K;
            run;
      %mend Ptable;
      %Ptable(TAB=Ptl3, Eff=EffectTL, Ua1=Ua1tl3, Um1=Um1tl3, Ua2=Ua2tl3,
Um2=Um2tl3, La1=La1tl3, Lm1=Lm1tl3, La2=La2tl3, Lm2=Lm2tl3, ROM=ROMtl3,
AREA=AREAtl3, NZ=NZtl3, NZromR=NZromRtl3, HA=HAtl3, H=Htl3, UK=UKtl3,
LK=LKtl3, K=Ktl3);            /*TL p-value*/
      %Ptable(TAB=PtlAR3, Eff=EffectTL, Ua1=Ua1tlAR3, Um1=Um1tlAR3,
Ua2=Ua2tlAR3, Um2=Um2tlAR3, La1=La1tlAR3, Lm1=Lm1tlAR3, La2=La2tlAR3,
Lm2=Lm2tlAR3, ROM=ROMtlAR3, AREA=AREAtlAR3, NZ=NZtlAR3, NZromR=NZromRtlAR3,
HA=HAtlAR3, H=HtlAR3, UK=UKtlAR3, LK=LKtlAR3, K=KtlAR3);          /*tlAR p-
value*/
      %Ptable(TAB=PtlFE3, Eff=EffectTL, Ua1=Ua1tlFE3, Um1=Um1tlFE3,
Ua2=Ua2tlFE3, Um2=Um2tlFE3, La1=La1tlFE3, Lm1=Lm1tlFE3, La2=La2tlFE3,
Lm2=Lm2tlFE3, ROM=ROMtlFE3, AREA=AREAtlFE3, NZ=NZtlFE3, NZromR=NZromRtlFE3,
HA=HAtlFE3, H=HtlFE3, UK=UKtlFE3, LK=LKtlFE3, K=KtlFE3);          /*tlFE p-
value*/
      %Ptable(TAB=PtlLB3, Eff=EffectTL, Ua1=Ua1tlLB3, Um1=Um1tlLB3,
Ua2=Ua2tlLB3, Um2=Um2tlLB3, La1=La1tlLB3, Lm1=Lm1tlLB3, La2=La2tlLB3,
Lm2=Lm2tlLB3, ROM=ROMtlLB3, AREA=AREAtlLB3, NZ=NZtlLB3, NZromR=NZromRtlLB3,
HA=HAtlLB3, H=HtlLB3, UK=UKtlLB3, LK=LKtlLB3, K=KtlLB3);          /*tlLB p-
value*/
      %Ptable(TAB=Ptl3nL, Eff=EffectTL, Ua1=Ua1tl3nL, Um1=Um1tl3nL,
Ua2=Ua2tl3nL, Um2=Um2tl3nL, La1=La1tl3nL, Lm1=Lm1tl3nL, La2=La2tl3nL,
Lm2=Lm2tl3nL, ROM=ROMtl3nL, AREA=AREAtl3nL, NZ=NZtl3nL, NZromR=NZromRtl3nL,
HA=HAtl3nL, H=Htl3nL, UK=UKtl3nL, LK=LKtl3nL, K=Ktl3nL);          /*TL Load-
norm p-value*/
      %Ptable(TAB=PtlAR3nL, Eff=EffectTL, Ua1=Ua1tlAR3nL, Um1=Um1tlAR3nL,
Ua2=Ua2tlAR3nL, Um2=Um2tlAR3nL, La1=La1tlAR3nL, Lm1=Lm1tlAR3nL,
La2=La2tlAR3nL, Lm2=Lm2tlAR3nL, ROM=ROMtlAR3nL, AREA=AREAtlAR3nL,
NZ=NZtlAR3nL, NZromR=NZromRtlAR3nL, HA=HAtlAR3nL, H=HtlAR3nL, UK=UKtlAR3nL,
LK=LKtlAR3nL, K=KtlAR3nL);          /*tlAR Load-norm p-value*/
      %Ptable(TAB=PtlFE3nL, Eff=EffectTL, Ua1=Ua1tlFE3nL, Um1=Um1tlFE3nL,
Ua2=Ua2tlFE3nL, Um2=Um2tlFE3nL, La1=La1tlFE3nL, Lm1=Lm1tlFE3nL,
La2=La2tlFE3nL, Lm2=Lm2tlFE3nL, ROM=ROMtlFE3nL, AREA=AREAtlFE3nL,
NZ=NZtlFE3nL, NZromR=NZromRtlFE3nL, HA=HAtlFE3nL, H=HtlFE3nL, UK=UKtlFE3nL,
LK=LKtlFE3nL, K=KtlFE3nL);          /*tlFE Load-norm p-value*/
      %Ptable(TAB=PtlLB3nL, Eff=EffectTL, Ua1=Ua1tlLB3nL, Um1=Um1tlLB3nL,
Ua2=Ua2tlLB3nL, Um2=Um2tlLB3nL, La1=La1tlLB3nL, Lm1=Lm1tlLB3nL,
La2=La2tlLB3nL, Lm2=Lm2tlLB3nL, ROM=ROMtlLB3nL, AREA=AREAtlLB3nL,
NZ=NZtlLB3nL, NZromR=NZromRtlLB3nL, HA=HAtlLB3nL, H=HtlLB3nL, UK=UKtlLB3nL,
LK=LKtlLB3nL, K=KtlLB3nL);          /*tlLB Load-norm p-value*/
      %Ptable(TAB=Ptl3nT, Eff=EffectTL, Ua1=Ua1tl3nT, Um1=Um1tl3nT,
Ua2=Ua2tl3nT, Um2=Um2tl3nT, La1=La1tl3nT, Lm1=Lm1tl3nT, La2=La2tl3nT,
Lm2=Lm2tl3nT, ROM=ROMtl3nT, AREA=AREAtl3nT, NZ=NZtl3nT, NZromR=NZromRtl3nT,
HA=HAtl3nT, H=Htl3nT, UK=UKtl3nT, LK=LKtl3nT, K=Ktl3nT);          /*TL Temp-
norm p-value*/
      %Ptable(TAB=PtlAR3nT, Eff=EffectTL, Ua1=Ua1tlAR3nT, Um1=Um1tlAR3nT,
Ua2=Ua2tlAR3nT, Um2=Um2tlAR3nT, La1=La1tlAR3nT, Lm1=Lm1tlAR3nT,
La2=La2tlAR3nT, Lm2=Lm2tlAR3nT, ROM=ROMtlAR3nT, AREA=AREAtlAR3nT,
NZ=NZtlAR3nT, NZromR=NZromRtlAR3nT, HA=HAtlAR3nT, H=HtlAR3nT, UK=UKtlAR3nT,
LK=LKtlAR3nT, K=KtlAR3nT);          /*tlAR Temp-norm p-value*/
```

```
	%Ptable(TAB=PtlFE3nT, Eff=EffectTL, Ua1=Ua1tlFE3nT,
Um1=Um1tlFE3nT, Ua2=Ua2tlFE3nT, Um2=Um2tlFE3nT, La1=La1tlFE3nT,
Lm1=Lm1tlFE3nT, La2=La2tlFE3nT, Lm2=Lm2tlFE3nT, ROM=ROMtlFE3nT,
AREA=AREAtlFE3nT, NZ=NZtlFE3nT, NZromR=NZromRtlFE3nT, HA=HAtlFE3nT,
H=HtlFE3nT, UK=UKtlFE3nT, LK=LKtlFE3nT, K=KtlFE3nT);        /*tlFE Temp-norm
p-value*/
	%Ptable(TAB=PtlLB3nT, Eff=EffectTL, Ua1=Ua1tlLB3nT, Um1=Um1tlLB3nT,
Ua2=Ua2tlLB3nT, Um2=Um2tlLB3nT, La1=La1tlLB3nT, Lm1=Lm1tlLB3nT,
La2=La2tlLB3nT, Lm2=Lm2tlLB3nT, ROM=ROMtlLB3nT, AREA=AREAtlLB3nT,
NZ=NZtlLB3nT, NZromR=NZromRtlLB3nT, HA=HAtlLB3nT, H=HtlLB3nT, UK=UKtlLB3nT,
LK=LKtlLB3nT, K=KtlLB3nT);          /*tlLB Temp-norm p-value*/

	quit; /*proc datasets*/

options orientation=portrait; /*page formatting*/ /*options ls=78 pageno=1 */
ods pdf file="&Path\Report_Ptables.pdf";  /*initialize pdf output*/

	/*Report p-value Tables*/
	%macro RepP(Ptable=, Ptitle=, w1=, w2=, w3=, w4=);
		title2 "&Ptitle";
		footnote "Statistically Significant: #=p<0.0001 *=p<&SS;
[blank]=p>&SS (insignificant)";

		proc report data=&Ptable nowd headline headskip;
			column Effect Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM;
			where Effect=&w1 or Effect=&w2 or Effect=&w3 or Effect=&w4;
			define Ua1/center format=pFMT.;
			define Um1/center format=pFMT.;
			define Ua2/center format=pFMT.;
			define Um2/center format=pFMT.;
			define La1/center format=pFMT.;
			define Lm1/center format=pFMT.;
			define La2/center format=pFMT.;
			define Lm2/center format=pFMT.;
			define ROM/center format=pFMT.;
			title3 "DIP-Boltzmann Paramaters";
		run;

		proc report data=&Ptable nowd headline headskip;
			column Effect ROM /*AREA*/ NZ /*NZromR*/  K /*HA*/ H /*UK*/
/*LK*/;
			where Effect=&w1 or Effect=&w2 or Effect=&w3 or Effect=&w4;
			define ROM/center format=pFMT.;
			define NZ/center format=pFMT.;
			define K/center format=pFMT.;
			define H/center format=pFMT.;
			title3 "Torque-Rotation Metrics";
		run;

	%mend RepP;
	%RepP(Ptable=Ptl3, Ptitle=TL p-Values, w1='Load', w2='Temp', w3='FSU',
w4='Dir'); /*TL p-values*/
	%RepP(Ptable=PtlAR3, Ptitle=tlAR p-Values, w1='Load', w2='Temp',
w3='FSU', w4=''); /*tlAR p-values*/
	%RepP(Ptable=PtlFE3, Ptitle=tlFE p-Values, w1='Load', w2='Temp',
w3='FSU', w4=''); /*tlFE p-values*/
```

```
      %RepP(Ptable=PtlLB3, Ptitle=tlLB p-Values, w1='Load', w2='Temp',
w3='FSU', w4=''); /*tlLB p-values*/
      %RepP(Ptable=Ptl3nL, Ptitle=TLLoadNorm p-Values, w1='Load',
w2='', w3='FSU', w4='Dir'); /*TLnorm p-values*/
      %RepP(Ptable=PtlAR3nL, Ptitle=tlARLoadNorm p-Values, w1='Load', w2='',
w3='FSU', w4=''); /*tlARnorm p-values*/
      %RepP(Ptable=PtlFE3nL, Ptitle=tlFELoadNorm p-Values, w1='Load', w2='',
w3='FSU', w4=''); /*tlFEnorm p-values*/
      %RepP(Ptable=PtlLB3nL, Ptitle=tlLBLoadNorm p-Values, w1='Load', w2='',
w3='FSU', w4=''); /*tlLBnorm p-values*/
      %RepP(Ptable=Ptl3nT, Ptitle=TLTempNorm p-Values, w1='', w2='Temp',
w3='FSU', w4='Dir'); /*TLnorm p-values*/
      %RepP(Ptable=PtlAR3nT, Ptitle=tlARTempNorm p-Values, w1='', w2='Temp',
w3='FSU', w4=''); /*tlARnorm p-values*/
      %RepP(Ptable=PtlFE3nT, Ptitle=tlFETempNorm p-Values, w1='', w2='Temp',
w3='FSU', w4=''); /*tlFEnorm p-values*/
      %RepP(Ptable=PtlLB3nT, Ptitle=tlLBTempNorm p-Values, w1='', w2='Temp',
w3='FSU', w4=''); /*tlLBnorm p-values*/

goptions reset=footnote;
ods pdf close;    /*close pdf output*/
ods rtf close;    /*close rtf output*/
ods html close;   /*close html output*/
```

D.2. Stepwise and Dynamic Loading Tests

```
/*========================================================================
Name: Dean Keith Stolworthy
Company: Brigham Young University (BYU)
Department: Mechanical Engineering
Laboratory: BYU Applied Biomechanics Engineering Laboratory (BABEL)

File: RATE_v17.sas

Summary: This program reads in the spine data, including test specimen,
test conditions, and the  Dual-inflection Point (DIP) Blotzmann parameters
(ROM, Ua1, Um1, Ua2, Um2, La1, Lm1, La2, Lm2), which were determined
previously using a least-squares method (Excel Solver).  Further calculations
are performed to determine metrics (Neutral Zone, Area, stiffness,
hysteresis)
that are commonly used to quantitatively describe the torque-rotation (TR)
response.
Each DIP-Boltzmann parameter and TR-metric is normalized with the
the same parameter (or metric) that was obtained at different testing
loading rate (Rate-Norm), but within the same test specimen, which includes
Spine+Segment (FSU) and testing temperature.  All of these tests were only
performed in the loading direction (DIR) of flexion-extension, therefore no
analysis was concerning the loading direction. Normalization is expected to
negate intra-specimen (FSU+Temp+DIR) variability while magnifying
interspecimen
(Rate)variability.
A multi-variable analysis of variance (MANOVA) was performed on the raw and
normalized datasets to determine which of the test conditions
(Temperature and/or Rate) affects the TR response, specified as p<0.05
(w/ alpha=0.05). An effort is made to predict the TR metrics at altered
testing conditions, which is accompanied by a Bland-Altman analysis comparing
the predicted to the actual TR metrics.
========================================================================*/
/*========================================================================
Revisions:
(1) Rate 6/9/2011
(2) Rate_v10 6/10/2011
(3) Rate_v11 6/22/2011
(4) Rate_v12 6/22/2011
(5) Rate_v13 7/14/2011
(6) Rate_v14 8/31/2011
(7) Rate_v15 9/2/2011
(8) Rate_v16 9/9/2011
(9) Rate_v17 10/5/2011
*/

goptions reset=all; /*Clear format settings*/
title1 "FE Rate Analysis";
*ods listing;           /*turn on output delivery system (ODS)*/
ods listing close;      /*turn off ODS*/

%let Path = C:\Users\Dean\Documents\1_School\Research\Thesis\4_DATA
Spreadsheets\PaperB_Rate\STAT\Rate_v18;
%let Tmax = 7.5; /*Nm*/
%let Tmin = -7.5; /*Nm*/
```

```
%let Tstep = 0.004;
%let SS = 0.05; /*Statistical Significance p-value, alpha<0.05*/
%let NZpercent = 0.85; /*range of NZ to use when calculating H and K*/

/*============Import Data============*/
      /* Import SW raw data from datafile */
      proc import out = WORK.DLP
            datafile =
'C:\Users\Dean\Documents\1_School\Research\Thesis\4_DATA
Spreadsheets\PaperB_Rate\STAT\RATEanalysis_v6.xlsx'
            dbms = EXCEL replace;
            range = "feDLP_Values$";
            getnames = YES;
            mixed = NO;
            scantext = YES;
            usedate = YES;
            scantime = YES;
      run;

      data DLP;set DLP;
            Dir='FE';
      run;

      /* Import SW raw data from datafile */
      proc import out = WORK.SW
            datafile =
'C:\Users\Dean\Documents\1_School\Research\Thesis\4_DATA
Spreadsheets\PaperB_Rate\STAT\RATEanalysis_v6.xlsx'
            dbms = EXCEL replace;
            range = "SW_Values$";
            getnames = YES;
            mixed = NO;
            scantext = YES;
            usedate = YES;
            scantime = YES;
      run;

/*============Create and filter datasets for analysis============*/
%macro makeDATA(raw=, rawNZkh=, rawNZ=, rawNR=, rawcR=, rawNT=, rawcT=);

      data &raw(drop=UAREA LAREA);
            set &raw(keep=Dir Spine Segment Rate Temp UA UB Ua1 Um1 Ua2 Um2
LA LB La1 Lm1 La2 Lm2 ROM AREA);
            if Ua1=. or Ua2=. or Um1=. or Um2=. or La1=. or La2=. or Lm1=. or
Lm2=. or UA=. or UB=. or LA=. or LB=. then delete;
            if Ua1=0.3 or Ua2=0.3 or Um1=0.3 or Um2=0.3 or La1=0.3 or La2=0.3
or Lm1=0.3 or Lm2=0.3 then delete;
            if ROM<=0 or AREA<=0 or ROM=. or AREA=. then delete;
            if segment='L4L5' then segment='L3L4'; /*L4L5 treated same as
L3L4*/
            if segment='L2L3' then segment='L1L2'; /*L2L3 treated same as
L1L2*/
            if spine='C070369' and segment='L1L2' then FSU='FSU1a';
            if spine='C070369' and segment='L3L4' then FSU='FSU1b';
            if spine='C070369' and segment='L5S1' then FSU='FSU1c';
            if spine='C090519' and segment='L1L2' then FSU='FSU2a';
            if spine='C090519' and segment='L3L4' then FSU='FSU2b';
```

```
            if spine='C090519' and segment='L5S1' then FSU='FSU2c';
            if spine='C091292' and segment='L1L2' then FSU='FSU3a';
            if spine='C091292' and segment='L3L4' then delete
/*FSU='FSU3b'*/;
            if spine='C091292' and segment='L5S1' then FSU='FSU3c';
            if spine='C091351' and segment='L1L2' then FSU='FSU4a';
            if spine='C091351' and segment='L3L4' then FSU='FSU4b';
            if spine='C091351' and segment='L5S1' then FSU='FSU4c';
            if spine='C100115' and segment='L1L2' then FSU='FSU5a';
            if spine='C100115' and segment='L3L4' then FSU='FSU5b';
            if spine='C100115' and segment='L5S1' then FSU='FSU5c';
            if spine='S090647' and segment='L1L2' then FSU='FSU6a';
            if spine='S090647' and segment='L3L4' then FSU='FSU6b';
            if spine='S090647' and segment='L5S1' then FSU='FSU6c';
            if spine='S091199' and segment='L1L2' then FSU='FSU7a';
            if spine='S091199' and segment='L3L4' then FSU='FSU7b';
            if spine='S091199' and segment='L5S1' then FSU='FSU7c';
            if spine='S100589' and segment='L1L2' then FSU='FSU8a';
            if spine='S100589' and segment='L3L4' then FSU='FSU8b';
            if spine='S100589' and segment='L5S1' then FSU='FSU8c';
            if spine='C070369' then Spine='Spine1';
            if spine='C090519' then Spine='Spine2';
            if spine='C091292' then Spine='Spine3';
            if spine='C091351' then Spine='Spine4';
            if spine='C100115' then Spine='Spine5';
            if spine='S090647' then Spine='Spine6';
            if spine='S091199' then Spine='Spine7';
            if spine='S100589' then Spine='Spine8';
            ROM = mean(abs(UB-UA),abs(LB-LA));
            UAREA = UA*(&Tmax-&Tmin) - UA/Ua1*log((1+exp(Ua1*(&Tmax-
Um1)))/(1+exp(Ua1*(&Tmin-Um1)))) + UB/Ua2*log((1+exp(Ua2*(&Tmax-
Um2)))/(1+exp(Ua2*(&Tmin-Um2))));
            LAREA = LA*(&Tmax-&Tmin) - LA/La1*log((1+exp(La1*(&Tmax-
Lm1)))/(1+exp(La1*(&Tmin-Lm1)))) + LB/La2*log((1+exp(La2*(&Tmax-
Lm2)))/(1+exp(La2*(&Tmin-Lm2))));
            AREA = UAREA - LAREA;
            HA = AREA/ROM;    /*HysteresisArea calculates the average spread
per degree of the ROM*/
      run;

      proc sort data=&raw;
            by Dir Temp FSU Rate ROM;
      run;

      /*Discrete rotation calculation of upper and lower DIP-Boltzmann
curves*/
      data &rawNZkh;
            set &raw;
            do m = &Tmin to &Tmax by &Tstep;
                  Utheta = UA/(1+exp(Ua1*(m-Um1))) - UB/(1+exp(Ua2*(m-Um2)))
+ UB; /*thetaUP*/
                  Ltheta = LA/(1+exp(La1*(m-Lm1))) - LB/(1+exp(La2*(m-Lm2)))
+ LB; /*thetaLOW*/
                  Dtheta = Utheta - Ltheta;
                  output;
            end;
      run;
```

```
	/*Determine NZ as the maximum rotation difference between upper
and lower curves*/
	proc means data=&rawNZkh (keep=Dir Temp FSU Rate ROM Dtheta) max
noprint;
		var Dtheta;
		by Dir Temp FSU Rate ROM;
		output out=&rawNZ(drop=_TYPE_ _FREQ_)
			max=NZ;
	run;

	/*Attach NZ to NZkh dataset */
	/*Set limit for calculating K and H, based on NZ*/
	/*Calculate derivative of upper and lower curves within a% of NZ*/
	data &rawNZkh (keep=Dir Temp FSU Rate ROM NZ mUP mLOW UK LK);
		merge &rawNZkh &rawNZ;
		by Dir Temp FSU Rate ROM;
		/*To get NZ flexibility coefficient, determine the slope of the
torque-rotation curve at rotation=0*/
		if Utheta>-&NZpercent*NZ/2 and Utheta<&NZpercent*NZ/2 then Uf = -
UA*Ua1*exp(Ua1*(m-Um1))/(1+exp(Ua1*(m-Um1)))**2 + UB*Ua2*exp(Ua2*(m-
Um2))/(1+exp(Ua2*(m-Um2)))**2;
			UK=1/Uf;	/* [Stiffness] = 1/[Flexibility] */
		if Ltheta>-&NZpercent*NZ/2 and Ltheta<&NZpercent*NZ/2 then Lf = -
LA*La1*exp(La1*(m-Lm1))/(1+exp(La1*(m-Lm1)))**2 + LB*La2*exp(La2*(m-
Lm2))/(1+exp(La2*(m-Lm2)))**2;
			LK=1/Lf;	/* [Stiffness] = 1/[Flexibility] */
		if Utheta>-&NZpercent*NZ/2 and Utheta<&NZpercent*NZ/2 then mUP =
m;
		if Ltheta>-&NZpercent*NZ/2 and Ltheta<&NZpercent*NZ/2 then mLOW =
m;
	run;

	/*Select UK, LK, mUP, and mLOW for each test subject (FSU+TEMP+DIR)*/
	proc means data=&rawNZkh mean noprint;
		var UK LK mUP mLOW;
		by Dir Temp FSU Rate ROM NZ; /*want UK, LK for each obs*/
		output out=&rawNZkh(drop=_TYPE_ _FREQ_)
			mean=UK LK mUP mLOW;
	run;

	/*Attach NZ UK LK to raw dataset*/
	data &raw(drop=mLOW mUP);
		merge &raw &rawNZkh;
		by Dir Temp FSU Rate ROM;
		K=mean(UK,LK); /*average stiffness coefficient of subject*/
		H=mLOW-mUP; /*hysteresis: focuses on the mid-portion of the
torque-rotation curve*/
		NZROMr=NZ/ROM;	/*NZ-to-ROM ratio*/
	run;

	/*Sort Raw SW data for normalizing*/
	proc sort data=&raw;
		by Dir FSU Temp Rate;
	run;

	/* Create normalizing variables for each Dir*Temp*FSU*/
```

```
            proc means data=&raw mean noprint;
                  var Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM NZ NZromR
AREA HA H UK LK K;
                  by Dir FSU Temp; /*Group*/
                  where Rate=1;     /*Control Variable @ Rate = 1 deg/sec*/
                  output out=&rawcR(drop=_TYPE_ _FREQ_)
                        mean=Ua1c Um1c Ua2c Um2c La1c Lm1c La2c Lm2c ROMc NZc
NZromRc AREAc HAc Hc UKc LKc Kc;
            run;

      /*Normalize raw data: grouping=FSU(Spine+Segment), Temp, Dir */
      data &rawNR(keep=Dir Spine Segment FSU Temp Rate Ua1 Um1 Ua2 Um2 La1
Lm1 La2 Lm2 ROM NZ NZromR AREA HA H UK LK K);
            merge &raw &rawcR;
            by Dir FSU Temp;
            Ua1 = Ua1/Ua1c;
            Um1 = Um1/Um1c;
            Ua2 = Ua2/Ua2c;
            Um2 = Um2/Um2c;
            La1 = La1/La1c;
            Lm1 = Lm1/Lm1c;
            La2 = La2/La2c;
            Lm2 = Lm2/Lm2c;
            ROM = ROM/ROMc;
            NZ = NZ/NZc;
            NZromR = NZromR/NZromRc;
            AREA = AREA/AREAc;
            HA = HA/HAc;
            H = H/Hc;
            UK = UK/UKc;
            LK = LK/LKc;
            K = K/Kc;
      run;



      /*Sort Raw data for temp-normalizing*/
      proc sort data=&raw;
            by Dir FSU Rate Temp;
      run;

      /* Create normalizing variables for each Dir*Temp*FSU*/
            proc means data=&raw mean noprint;
                  var Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM NZ NZromR AREA HA H
UK LK K;
                  by Dir FSU Rate; /*Group*/
                  where Temp='BODY';      /*Control Variable @ Rate = 1
deg/sec*/
                  output out=&rawcT(drop=_TYPE_ _FREQ_)
                        mean=Ua1c Um1c Ua2c Um2c La1c Lm1c La2c Lm2c ROMc NZc
NZromRc AREAc HAc Hc UKc LKc Kc;
            run;

      /*Normalize raw data: grouping=FSU(Spine+Segment), Temp, Dir */
      data &rawNT(keep=Dir Spine Segment FSU Temp Rate Ua1 Um1 Ua2 Um2 La1
Lm1 La2 Lm2 ROM NZ NZromR AREA HA H UK LK K);
            merge &raw &rawcT;
```

```
            by Dir FSU Rate;
            Ua1 = Ua1/Ua1c;
            Um1 = Um1/Um1c;
            Ua2 = Ua2/Ua2c;
            Um2 = Um2/Um2c;
            La1 = La1/La1c;
            Lm1 = Lm1/Lm1c;
            La2 = La2/La2c;
            Lm2 = Lm2/Lm2c;
            ROM = ROM/ROMc;
            NZ = NZ/NZc;
            NZromR = NZromR/NZromRc;
            AREA = AREA/AREAc;
            HA = HA/HAc;
            H = H/Hc;
            UK = UK/UKc;
            LK = LK/LKc;
            K = K/Kc;
      run;

      /*delete temporary dataset*/
      proc datasets library=work;
            delete &rawNZkh &rawNZ &rawcR &rawcT;
      run;quit;

      data &raw; set &raw;
            if UK=. or LK=. or ROM=. or NZ=. or AREA=. or H=. or NZROMr=.
then delete;
      run;

      data &rawNR; set &rawNR;
            if UK=. or LK=. or ROM=. or NZ=. or AREA=. or H=. or NZROMr=.
then delete;
      run;

      data &rawNT; set &rawNT;
            if UK=. or LK=. or ROM=. or NZ=. or AREA=. or H=. or NZROMr=.
then delete;
      run;

%mend makeDATA;
%makeDATA(raw=DLP, rawNZkh=DLPnzKH, rawNZ=DLPnz, rawNR=DLPnR, rawcR=DLPcR,
rawNT=DLPnT, rawcT=DLPcT);
%makeDATA(raw=SW, rawNZkh=SWnzKH, rawNZ=SWnz, rawNR=SWnR, rawcR=SWcR,
rawNT=SWnT, rawcT=SWcT);


/*==================Report Analysis Datasets, raw and
normalized=============*/
options orientation=portrait; /*page formatting*/ /*page formatting*/
/*options 1s=78 pageno=1 */
ods pdf file="&Path\DATA.pdf";
ods rtf file="&Path\DATA.rtf";

%macro rawREPORT(FIN=, titDIP=, titR=, FINset=);
      /* Report DIP-Boltzmann Data */
      proc report data=&FIN nowd headline headskip;
```

```
            column Temp Dir Spine Segment Rate Ua1 Um1 Ua2 Um2 La1 Lm1
La2 Lm2 ROM;
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Rate / center;
            define Ua1 / center format=6.4;
            define Um1 / center format=6.4;
            define Ua2 / center format=6.4;
            define Um2 / center format=6.4;
            define La1 / center format=6.4;
            define Lm1 / center format=6.4;
            define La2 / center format=6.4;
            define Lm2 / center format=6.4;
            define ROM / center format=6.4;
            title2 "&FIN &titDIP";
      run;

      /*Report Calculated Flexibility Data*/
      proc report data=&FIN nowd headline headskip;
            column Temp Dir Spine Segment Rate ROM AREA NZ NZROMr HA H UK LK
K;
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Rate / center;
            define ROM / center format=6.4;
            define AREA / center format=6.4;
            define HA / center format=6.4;
            define H / center format=6.4;
            define NZ / center format=6.4;
            define NZROMr / center 'NZ\ROM' format=6.4;
            define UK / center format=6.4;
            define LK / center format=6.4;
            define K / center format=6.4;
            title2 "&titR";
      run;

%mend rawReport;
%rawREPORT(FIN=DLP, titDIP=DIP-Boltzmann Data, titR=DLP Flexibility Raw
Data);
%rawREPORT(FIN=SW , titDIP=DIP-Boltzmann Data, titR=SW Flexibility Raw Data);

%macro dataREPORT(FIN=, titDIP=, titR=, FINset=, VAR=, VARfiltn=, VARfilt=);
      /* Report DIP-Boltzmann Data */
      proc report data=&FIN nowd headline headskip;
            column Temp Dir Spine Segment Rate Ua1 Um1 Ua2 Um2 La1 Lm1 La2
Lm2 ROM;
            where &VAR ne &VARFILTn;
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Rate / center;
            define Ua1 / center format=6.4;
            define Um1 / center format=6.4;
            define Ua2 / center format=6.4;
            define Um2 / center format=6.4;
```

```
            define La1 / center format=6.4;
            define Lm1 / center format=6.4;
            define La2 / center format=6.4;
            define Lm2 / center format=6.4;
            define ROM / center format=6.4;
            title2 "&FIN &titDIP";
            footnote "Normalized observations are identity for &VAR =
&VARfilt";
      run;

      /*Report Calculated Flexibility Data*/
      proc report data=&FIN nowd headline headskip;
            column Temp Dir Spine Segment Rate ROM AREA NZ NZROMr HA H UK LK
K;
            where &VAR ne &VARFILTn;
            define Temp / display center;
            define Dir / display center;
            define Segment / display center width=7;
            define Rate / center;
            define ROM / center format=6.4;
            define AREA / center format=6.4;
            define HA / center format=6.4;
            define H / center format=6.4;
            define NZ / center format=6.4;
            define NZROMr / center 'NZ\ROM' format=6.4;
            define UK / center format=6.4;
            define LK / center format=6.4;
            define K / center format=6.4;
            title2 "&titR";
            footnote "Normalized observations are identity for &VAR =
&VARfilt";
      run;

%mend dataReport;
%dataREPORT(FIN=DLPnR, titDIP=DIP-Boltzmann Data, titR=DLPrateNorm
Flexibility Data, VAR=Rate, VARfiltn=1, VARfilt=CS @ 1deg/sec);
%dataREPORT(FIN=SWnR, titDIP=DIP-Boltzmann Data, titR=SWrateNorm Flexibility
Data (SW/CS), VAR=Rate, VARfiltn=1, VARfilt=CS @ 1deg/sec);
%dataREPORT(FIN=SWnT, titDIP=DIP-Boltzmann Data, titR=SWtempNorm Flexibility
Data (Room/Body), VAR=Temp, VARfiltn='BODY', VARfilt=Body Temp);


      /* SW data seperated by loading direction*/
      data swAR; set SW;       if Dir='AR'; run;
      data swFE; set SW;       if Dir='FE'; run;
      data swLB; set SW;       if Dir='LB'; run;
      data swARnR; set SWnR;   if Dir='AR'; run;
      data swFEnR; set SWnR;   if Dir='FE'; run;
      data swLBnR; set SWnR;   if Dir='LB'; run;
      data swARnT; set SWnT;   if Dir='AR'; run;
      data swFEnT; set SWnT;   if Dir='FE'; run;
      data swLBnT; set SWnT;   if Dir='LB'; run;

      /*swFE&DLP data combined and sorted*/
      data FE; set swFE DLP;
            proc sort data=FE; by Temp Rate;
      run;
```

```
	/*swFE&DLP Normalized data combined and sorted*/
	data FEnR; set swFEnR DLPnR;
		proc sort data=FEnR; by Temp Rate;
	run;

	/*swFE&DLP Normalized data combined and sorted*/
	data FEnT; set swFEnT DLPnT;
		proc sort data=FEnT; by Rate Temp;
	run;

/*Box-Plots of rawData/Grouped by Dir*/
goptions reset=footnote symbol;
ods listing close;

symbol1 v=Y i=none cv=red ci=red co=red;
symbol2 v=triangle i=none cv=blue ci=blue co=blue;
symbol3 v=square i=none cv=red ci=red co=red;
symbol4 v=dot i=none cv=blue ci=blue co=blue;
symbol5 v=plus i=none cv=red ci=red co=red;
symbol6 v=- i=none cv=blue ci=blue co=blue;
symbol7 v== i=none cv=red ci=red co=red;
symbol8 v=star i=none cv=blue ci=blue co=blue;
symbol9 v=X i=none cv=red ci=red co=red;
symbol10 v=hash i=none cv=blue ci=blue co=blue;
symbol11 v=+ i=none cv=red ci=red co=red;


%macro boxMACRO(dataset=, var=, t2=);
	title2 "&t2";

	proc sort data=&dataset;
		by Dir Rate Temp;
	run;

	proc boxplot data=&dataset;
		by Dir;
		plot &var*Rate;
			label	&var = "&t2" Temp='Temperature';
	run;

	proc boxplot data=&dataset;
		by Dir;
		plot &var*Temp=Rate;
			label	&var = "&t2" Temp='Temperature';
	run;
%mend;
%boxMACRO(dataset=FE, var=ROM, t2=Range of Motion);
%boxMACRO(dataset=FE, var=AREA, t2=Area);
%boxMACRO(dataset=FE, var=NZ, t2=Neutral Zone);
%boxMACRO(dataset=FE, var=NZromR, t2=NZ-ROM-ratio);
%boxMACRO(dataset=FE, var=HA, t2=Hysteresis Area);
%boxMACRO(dataset=FE, var=H, t2=Hysteresis);
%boxMACRO(dataset=FE, var=UK, t2=Upper Stiffness);
%boxMACRO(dataset=FE, var=LK, t2=Lower Stiffness);
%boxMACRO(dataset=FE, var=K, t2=Stiffness);
%boxMACRO(dataset=FE, var=Ua1, t2=alpha1UPPER);
```

```
%boxMACRO(dataset=FE, var=Um1, t2=m1UPPER);
%boxMACRO(dataset=FE, var=Ua2, t2=alpha2UPPER);
%boxMACRO(dataset=FE, var=Um2, t2=m2UPPER);
%boxMACRO(dataset=FE, var=La1, t2=alpha1LOWER);
%boxMACRO(dataset=FE, var=Lm1, t2=M1LOWER);
%boxMACRO(dataset=FE, var=La2, t2=alpha2LOWER);
%boxMACRO(dataset=FE, var=Lm2, t2=m2LOWER);
%boxMACRO(dataset=FEnR, var=ROM, t2=Range of Motion);
%boxMACRO(dataset=FEnR, var=AREA, t2=Area);
%boxMACRO(dataset=FEnR, var=NZ, t2=Neutral Zone);
%boxMACRO(dataset=FEnR, var=NZromR, t2=NZ-ROM-ratio);
%boxMACRO(dataset=FEnR, var=HA, t2=Hysteresis Area);
%boxMACRO(dataset=FEnR, var=H, t2=Hysteresis);
%boxMACRO(dataset=FEnR, var=UK, t2=Upper Stiffness);
%boxMACRO(dataset=FEnR, var=LK, t2=Lower Stiffness);
%boxMACRO(dataset=FEnR, var=K, t2=Stiffness);
%boxMACRO(dataset=FEnR, var=Ua1, t2=alpha1UPPER);
%boxMACRO(dataset=FEnR, var=Um1, t2=m1UPPER);
%boxMACRO(dataset=FEnR, var=Ua2, t2=alpha2UPPER);
%boxMACRO(dataset=FEnR, var=Um2, t2=m2UPPER);
%boxMACRO(dataset=FEnR, var=La1, t2=alpha1LOWER);
%boxMACRO(dataset=FEnR, var=Lm1, t2=M1LOWER);
%boxMACRO(dataset=FEnR, var=La2, t2=alpha2LOWER);
%boxMACRO(dataset=FEnR, var=Lm2, t2=m2LOWER);
%boxMACRO(dataset=FEnT, var=ROM, t2=Range of Motion);
%boxMACRO(dataset=FEnT, var=AREA, t2=Area);
%boxMACRO(dataset=FEnT, var=NZ, t2=Neutral Zone);
%boxMACRO(dataset=FEnT, var=NZromR, t2=NZ-ROM-ratio);
%boxMACRO(dataset=FEnT, var=HA, t2=Hysteresis Area);
%boxMACRO(dataset=FEnT, var=H, t2=Hysteresis);
%boxMACRO(dataset=FEnT, var=UK, t2=Upper Stiffness);
%boxMACRO(dataset=FEnT, var=LK, t2=Lower Stiffness);
%boxMACRO(dataset=FEnT, var=K, t2=Stiffness);
%boxMACRO(dataset=FEnT, var=Ua1, t2=alpha1UPPER);
%boxMACRO(dataset=FEnT, var=Um1, t2=m1UPPER);
%boxMACRO(dataset=FEnT, var=Ua2, t2=alpha2UPPER);
%boxMACRO(dataset=FEnT, var=Um2, t2=m2UPPER);
%boxMACRO(dataset=FEnT, var=La1, t2=alpha1LOWER);
%boxMACRO(dataset=FEnT, var=Lm1, t2=M1LOWER);
%boxMACRO(dataset=FEnT, var=La2, t2=alpha2LOWER);
%boxMACRO(dataset=FEnT, var=Lm2, t2=m2LOWER);

ods rtf close;
ods pdf close;

ods listing close;      /*Turn off ODS listing*/
/*================Perform Mixed-Models Analysis on DIP-Boltzmann and
Flexbility Data===================*/
%macro MixAn(dlpDAT=, swfeDAT=, dvar=, dlp3=, swFE3=, dlpLS=, swFELS=);
/* Perform MANOVA for (model=&dvar) variables of the selected datasets*/
      /* MANOVA of DLPxx */
      proc mixed data=&dlpDAT maxiter=100;
          class Rate Temp Spine Segment FSU;
          model &dvar = Rate Temp FSU(Temp) Rate(Temp);
          random Rate/subject=FSU(Temp);
          lsmeans Rate(Temp)/pdiff adjust=tukey;
          title "MANOVA for DLP DIP-Boltzman &dvar ";
```

```
            ods output Tests3 = &dlp3(keep=ProbF) LSmeans =
&dlpLS(keep=Temp Rate Estimate StdErr);
      run;

      /* MANOVA of swFE */
      proc mixed data=&swfeDAT;
          class Rate Temp Spine Segment FSU;
          model &dvar = Rate Temp FSU Rate*Temp;
            random Rate/subject=FSU*Temp;
            lsmeans Rate*Temp/pdiff adjust=tukey;
          title2 "MANOVA for swFE DIP-Boltzmann &dvar";
            ods output Tests3 = &swFE3(keep=ProbF) LSmeans =
&swfeLS(keep=Temp Rate Estimate StdErr);
      run;

%mend MixAn;
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=Ua1, dlp3=Ua1dlp3, swFE3=Ua1swFE3,
dlpLS=Ua1dlpLS, swFELS=Ua1swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=Um1, dlp3=Um1dlp3, swFE3=Um1swFE3,
dlpLS=Um1dlpLS, swFELS=Um1swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=Ua2, dlp3=Ua2dlp3, swFE3=Ua2swFE3,
dlpLS=Ua2dlpLS, swFELS=Ua2swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=Um2, dlp3=Um2dlp3, swFE3=Um2swFE3,
dlpLS=Um2dlpLS, swFELS=Um2swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=La1, dlp3=La1dlp3, swFE3=La1swFE3,
dlpLS=La1dlpLS, swFELS=La1swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=Lm1, dlp3=Lm1dlp3, swFE3=Lm1swFE3,
dlpLS=Lm1dlpLS, swFELS=Lm1swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=La2, dlp3=La2dlp3, swFE3=La2swFE3,
dlpLS=La1dlpLS, swFELS=La2swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=Lm2, dlp3=Lm2dlp3, swFE3=Lm2swFE3,
dlpLS=Lm2dlpLS, swFELS=Lm2swFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=ROM, dlp3=ROMdlp3, swFE3=ROMswFE3,
dlpLS=ROMdlpLS, swFELS=ROMswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=Area, dlp3=Areadlp3, swFE3=AREAswFE3,
dlpLS=AREAdlpLS, swFELS=AREAswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=H, dlp3=Hdlp3, swFE3=HswFE3,
dlpLS=HdlpLS, swFELS=HswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=HA, dlp3=HAdlp3, swFE3=HAswFE3,
dlpLS=HAdlpLS, swFELS=HAswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=NZ, dlp3=NZdlp3, swFE3=NZswFE3,
dlpLS=NZdlpLS, swFELS=NZswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=NZromR, dlp3=NZromRdlp3,
swFE3=NZromRswFE3, dlpLS=NZromRdlpLS, swFELS=NZromRswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=UK, dlp3=UKdlp3, swFE3=UKswFE3,
dlpLS=UKdlpLS, swFELS=UKswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=LK, dlp3=LKdlp3, swFE3=LKswFE3,
dlpLS=LKdlpLS, swFELS=LKswFELS);
%MixAn(dlpDAT=DLP, swfeDAT=swFE, dvar=K, dlp3=Kdlp3, swFE3=KswFE3,
dlpLS=KdlpLS, swFELS=KswFELS);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=Ua1, dlp3=Ua1dlp3nR,
swFE3=Ua1swFE3nR, dlpLS=Ua1dlpLSnR, swFELS=Ua1swFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=Um1, dlp3=Um1dlp3nR,
swFE3=Um1swFE3nR, dlpLS=Um1dlpLSnR, swFELS=Um1swFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=Ua2, dlp3=Ua2dlp3nR,
swFE3=Ua2swFE3nR, dlpLS=Ua2dlpLSnR, swFELS=Ua2swFELSnR);
```

```
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=Um2, dlp3=Um2dlp3nR,
swFE3=Um2swFE3nR, dlpLS=Um2dlpLSnR, swFELS=Um2swFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=La1, dlp3=La1dlp3nR,
swFE3=La1swFE3nR, dlpLS=La1dlpLSnR, swFELS=La1swFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=Lm1, dlp3=Lm1dlp3nR,
swFE3=Lm1swFE3nR, dlpLS=Lm1dlpLSnR, swFELS=Lm1swFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=La2, dlp3=La2dlp3nR,
swFE3=La2swFE3nR, dlpLS=La2dlpLSnR, swFELS=La2swFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=Lm2, dlp3=Lm2dlp3nR,
swFE3=Lm2swFE3nR, dlpLS=Lm2dlpLSnR, swFELS=Lm2swFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=ROM, dlp3=ROMdlp3nR,
swFE3=ROMswFE3nR, dlpLS=ROMdlpLSnR, swFELS=ROMswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=Area, dlp3=Areadlp3nR,
swFE3=AREAswFE3nR, dlpLS=AREAdlpLSnR, swFELS=AREAswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=H, dlp3=Hdlp3nR, swFE3=HswFE3nR,
dlpLS=HdlpLSnR, swFELS=HswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=HA, dlp3=HAdlp3nR, swFE3=HAswFE3nR,
dlpLS=HAdlpLSnR, swFELS=HAswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=NZ, dlp3=NZdlp3nR, swFE3=NZswFE3nR,
dlpLS=NZdlpLSnR, swFELS=NZswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=NZromR, dlp3=NZromRdlp3nR,
swFE3=NZromRswFE3nR, dlpLS=NZromRdlpLSnR, swFELS=NZromRswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=UK, dlp3=UKdlp3nR, swFE3=UKswFE3nR,
dlpLS=UKdlpLSnR, swFELS=UKswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=LK, dlp3=LKdlp3nR, swFE3=LKswFE3nR,
dlpLS=LKdlpLSnR, swFELS=LKswFELSnR);
%MixAn(dlpDAT=DLPnR, swfeDAT=swFEnR, dvar=K, dlp3=Kdlp3nR, swFE3=KswFE3nR,
dlpLS=KdlpLSnR, swFELS=KswFELSnR);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=Ua1, dlp3=Ua1dlp3nT,
swFE3=Ua1swFE3nT, dlpLS=Ua1dlpLSnT, swFELS=Ua1swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=Um1, dlp3=Um1dlp3nT,
swFE3=Um1swFE3nT, dlpLS=Um1dlpLSnT, swFELS=Um1swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=Ua2, dlp3=Ua2dlp3nT,
swFE3=Ua2swFE3nT, dlpLS=Ua2dlpLSnT, swFELS=Ua2swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=Um2, dlp3=Um2dlp3nT,
swFE3=Um2swFE3nT, dlpLS=Um2dlpLSnT, swFELS=Um2swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=La1, dlp3=La1dlp3nT,
swFE3=La1swFE3nT, dlpLS=La1dlpLSnT, swFELS=La1swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=Lm1, dlp3=Lm1dlp3nT,
swFE3=Lm1swFE3nT, dlpLS=Lm1dlpLSnT, swFELS=Lm1swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=La2, dlp3=La2dlp3nT,
swFE3=La2swFE3nT, dlpLS=La2dlpLSnT, swFELS=La2swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=Lm2, dlp3=Lm2dlp3nT,
swFE3=Lm2swFE3nT, dlpLS=Lm2dlpLSnT, swFELS=Lm2swFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=ROM, dlp3=ROMdlp3nT,
swFE3=ROMswFE3nT, dlpLS=ROMdlpLSnT, swFELS=ROMswFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=Area, dlp3=Areadlp3nT,
swFE3=AREAswFE3nT, dlpLS=AREAdlpLSnT, swFELS=AREAswFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=H, dlp3=Hdlp3nT, swFE3=HswFE3nT,
dlpLS=HdlpLSnT, swFELS=HswFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=HA, dlp3=HAdlp3nT, swFE3=HAswFE3nT,
dlpLS=HAdlpLSnT, swFELS=HAswFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=NZ, dlp3=NZdlp3nT, swFE3=NZswFE3nT,
dlpLS=NZdlpLSnT, swFELS=NZswFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=NZromR, dlp3=NZromRdlp3nT,
swFE3=NZromRswFE3nT, dlpLS=NZromRdlpLSnT, swFELS=NZromRswFELSnT);
```

```
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=UK, dlp3=UKdlp3nT,
swFE3=UKswFE3nT, dlpLS=UKdlpLSnT, swFELS=UKswFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=LK, dlp3=LKdlp3nT,
swFE3=LKswFE3nT, dlpLS=LKdlpLSnT, swFELS=LKswFELSnT);
%MixAn(dlpDAT=DLPnT, swfeDAT=swFEnT, dvar=K, dlp3=Kdlp3nT, swFE3=KswFE3nT,
dlpLS=KdlpLSnT, swFELS=KswFELSnT);

/*==============================================================
Begin HTML OUTPUT
==============================================================*/
goptions reset=all; /*Clear all output format settings*/
title1 "FE Rate Analysis"; /*Set title1*/

ods html path="&Path" (url=none)    /*Initialize html output*/
      body="body.html"
      contents="toc.html"
      frame="frame.html"
      style=minimal;

/*====================Summarize Data====================*/
options orientation=portrait;
ods rtf file="&Path\Results.rtf";   /*Initialize rtf output*/
ods pdf file="&Path/Summary.pdf";   /*Initialize pdf output*/

%macro Summary(dat=, AvgDAT=, StdDAT=, summTABLE=, sort1=, sort2=, sort3=);
      /* Sort filtered data for proc means*/
      proc sort data=&dat;
            by &sort1 &sort2 &sort3;
      run;

      /*Produce means and std for SW Reporting*/
      proc means data=&dat mean std noprint;
            var Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM AREA NZ NZromR HA H UK LK
K;
            where Dir = 'FE';
            by &sort1 &sort2 &sort3;
            output out=&AvgDAT
                  mean = avgUa1 avgUm1 avgUa2 avgUm2 avgLa1 avgLm1 avgLa2
avgLm2 avgROM avgAREA avgNZ avgNZromR avgHA avgH avgUK avgLK avgK;
            output out=&StdDAT
                  std = stdUa1 stdUm1 stdUa2 stdUm2 stdLa1 stdLm1 stdLa2
stdLm2 stdROM stdAREA stdNZ stdNZromR stdHA stdH stdUK stdLK stdK;
      run;

      /*Compile and format means results*/
      data &summTABLE(drop = _TYPE_ _FREQ_);
            merge &AvgDAT &StdDAT;
            asROM = cat(put(AvgROM,5.3), ' (', put(StdROM,5.3), ')');
            asAREA = cat(put(AvgAREA,5.3), ' (', put(StdAREA,5.3), ')');
            asNZ = cat(put(AvgNZ,5.3), ' (', put(StdNZ,5.3), ')');
            asNZROMr = cat(put(AvgNZROMr,5.3), ' (', put(StdNZROMr,5.3),
')');
            asHA = cat(put(AvgHA,5.3), ' (', put(StdHA,5.3), ')');
            asH = cat(put(AvgH,5.3), ' (', put(StdH,5.3), ')');
            asUK = cat(put(AvgUK,5.3), ' (', put(StdUK,5.3), ')');
            asLK = cat(put(AvgLK,5.3), ' (', put(StdLK,5.3), ')');
            asK = cat(put(AvgK,5.3), ' (', put(StdK,5.3), ')');
```

```
        asUa1 = cat(put(AvgUa1,5.3), ' (', put(StdUa1,5.3), ')');
        asUm1 = cat(put(AvgUm1,5.3), ' (', put(StdUm1,5.3), ')');
        asUa2 = cat(put(AvgUa2,5.3), ' (', put(StdUa2,5.3), ')');
        asUm2 = cat(put(AvgUm2,5.3), ' (', put(StdUm2,5.3), ')');
        asLa1 = cat(put(AvgLa1,5.3), ' (', put(StdLa1,5.3), ')');
        asLm1 = cat(put(AvgLm1,5.3), ' (', put(StdLm1,5.3), ')');
        asLa2 = cat(put(AvgLa2,5.3), ' (', put(StdLa2,5.3), ')');
        asLm2 = cat(put(AvgLm2,5.3), ' (', put(StdLm2,5.3), ')');
    run;

%mend Summary;
%Summary(dat=DLP, AvgDAT=AvgDLP, StdDAT=StdDLP, summTABLE=DLPtable,
sort1=Dir, sort2=Temp, sort3=Rate);
%Summary(dat=DLPnR, AvgDAT=AvgDLPnR, StdDAT=StdDLPnR, summTABLE=DLPnRtable,
sort1=Dir, sort2=Temp, sort3=Rate);
%Summary(dat=SWfe, AvgDAT=AvgSW, StdDAT=StdSW, summTABLE=SWtable, sort1=Dir,
sort2=Temp, sort3=Rate);
%Summary(dat=SWfenR, AvgDAT=AvgSWnR, StdDAT=StdSWnR, summTABLE=SWnrTable,
sort1=Dir, sort2=Temp, sort3=Rate);
%Summary(dat=SWfenT,  AvgDAT=AvgSWnT,  StdDAT=StdSWnT,  summTABLE=SWntTable,
sort1=Dir, sort2=Rate, sort3=Temp);

%macro SummRep(Table=, nrTable=, ntTable=, Title=, nrTitle=, ntTitle=);

    /*Report stiffness Data Summary*/
    proc report data=&Table headline headskip nowd;
        column DIR TEMP Rate asROM asAREA asNZ asNZromR asHA asH asK;
        where DIR='FE';
        define DIR/order center;
        define TEMP/order center;
        define Rate/center;
        define asROM/'ROM' center;
        define asAREA/'Area' center;
        define asNZ/'NZ' center;
        define asNZromR/'NZromR' center;
        define asHA/'HA' center;
        define asH/'H' center;
        define asK/'K' center;
        title2 "&Title";
    run;

    /*Report rate-normal stiffness Data Summary*/
    proc report data=&nrTable headline headskip nowd;
        column DIR TEMP Rate asROM asAREA asNZ asNZromR asHA asH asK;
        where DIR='FE';
        define DIR/order center;
        define TEMP/order center;
        define Rate/center;
        define asROM/'ROM' center;
        define asAREA/'Area' center;
        define asNZ/'NZ' center;
        define asNZromR/'NZromR' center;
        define asHA/'HA' center;
        define asH/'H' center;
        define asK/'K' center;
        title2 "&nrTitle";
```

```
            footnote "All results are identity for control-group (1
deg/sec) results";
      run;

      /*Report temp-normal stiffness Data Summary*/
      proc report data=&ntTable headline headskip nowd;
            column DIR TEMP Rate asROM asAREA asNZ asNZromR asHA asH asK;
            where DIR='FE';
            define DIR/order center;
            define TEMP/order center;
            define Rate/center;
            define asROM/'ROM' center;
            define asAREA/'Area' center;
            define asNZ/'NZ' center;
            define asNZromR/'NZromR' center;
            define asHA/'HA' center;
            define asH/'H' center;
            define asK/'K' center;
            title2 "&ntTitle";
            footnote "All results are identity for control-group (Body Temp)
results";
      run;

goptions reset=footnote;

%mend SummRep;
%SummRep(Table=DLPtable, nrTable=DLPnrTable, ntTable=DLPntTable,
Title=Continuous-Speed Flexibility Summary, nrTitle=Rate-Normalized
Flexibility Summary);
%SummRep(Table=SWtable, nrTable=SWnrTable, ntTable=SWntTable, Title=Stepwise
Flexibility Summary, nrTitle=Rate-Normalized Flexibility Summary,
ntTitle=Temp-Normalized Flexibility Summary);

/* SW Frequencies */
proc freq data=SWfe;
      tables Spine*Segment Rate*Temp FSU/nocol norow nocum;
      title2 'SW Frequencies';
run;

/* DLP Frequencies */
proc freq data=DLP;
      tables Spine*Segment Rate*Temp FSU/nocol norow nocum;
      title2 'DLP Frequencies';
run;

ods pdf close;    /*close pdf output*/

/*===============Organize P-table Probability Analysis================*/

/*Create user-defined format for p-value tables*/
proc format;
      value pFMT
      low-<.0001=" # "
      .0001-<&SS=" * "
      &SS-high="  ";
run;
```

```
	/*create row names for p-values table*/
	data Effects;
		input Effect $;
		datalines;
		Rate
		Temp
		FSU
		R*T
		;
	data EffectSW;
		input Effect $;
		datalines;
		Rate
		Temp
		FSU
		R*T
		Dir
		;

	/*Organize p-value tables*/
	%macro	Ptable(TAB=, Eff=, Ua1=, Um1=, Ua2=, Um2=, La1=, Lm1=,
La2=, Lm2=, ROM=, NZ=, NZromR=, AREA=, HA=, H=, UK=, LK=, K=); /*DLP p-
value*/

		data &TAB;
			merge &Eff
				&Ua1(rename=(ProbF=Ua1)) &Um1(rename=(ProbF=Um1))
&Ua2(rename=(ProbF=Ua2)) &Um2(rename=(ProbF=Um2))
				&La1(rename=(ProbF=La1)) &Lm1(rename=(ProbF=Lm1))
&La2(rename=(ProbF=La2)) &Lm2(rename=(ProbF=Lm2))
				&ROM(rename=(ProbF=ROM)) &AREA(rename=(ProbF=Area))
&NZ(rename=(ProbF=NZ)) &NZromR(rename=(ProbF=NZromR))
				&HA(rename=(ProbF=HA)) &H(rename=(ProbF=H))
	&UK(rename=(ProbF=UK)) &LK(rename=(ProbF=LK)) &K(rename=(ProbF=K));
			label ROM='ROM' Area='Area' NZ='NZ' NZromR='NZromR' HA='HA'
H='H' UK='UK' LK ='LK' K='K'
				Ua1='Ua1' Um1='Um1' Ua2='Ua2' Um2='Um2' La1='La1'
Lm1='Lm1' La2='La2' Lm2='Lm2';
			*format Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM AREA H NZ UK LK
K pFMT.; /*apply format*/
		run;

	*	proc datasets library=work;
	*		delete &Ua1 &Um1 &Ua2 &Um2 &La1 &Lm1 &La2 &Lm2 &ROM &AREA
&NZ &NZromR &HA &H &UK &LK &K;
	*	run;
	%mend Ptable;
	%Ptable(TAB=Pdlp3, Eff=Effects, Ua1=Ua1dlp3, Um1=Um1dlp3, Ua2=Ua2dlp3,
Um2=Um2dlp3, La1=La1dlp3, Lm1=Lm1dlp3, La2=La2dlp3, Lm2=Lm2dlp3, ROM=ROMdlp3,
NZ=NZdlp3, NZromR=NZromRdlp3, AREA=AREAdlp3, HA=HAdlp3, H=Hdlp3, UK=UKdlp3,
LK=LKdlp3, K=Kdlp3); /*DLP p-value*/
	%Ptable(TAB=Pdlp3nR, Eff=Effects, Ua1=Ua1dlp3nR, Um1=Um1dlp3nR,
Ua2=Ua2dlp3nR, Um2=Um2dlp3nR, La1=La1dlp3nR, Lm1=Lm1dlp3nR, La2=La2dlp3nR,
Lm2=Lm2dlp3nR, ROM=ROMdlp3nR, NZ=NZdlp3nR, NZromR=NZromRdlp3nR,
AREA=AREAdlp3nR, HA=HAdlp3nR, H=Hdlp3nR, UK=UKdlp3nR, LK=LKdlp3nR,
K=Kdlp3nR); /*DLP Rate-norm p-value*/
```

```
      %Ptable(TAB=PswFE3, Eff=EffectSW, Ua1=Ua1swFE3, Um1=Um1swFE3,
Ua2=Ua2swFE3, Um2=Um2swFE3, La1=La1swFE3, Lm1=Lm1swFE3, La2=La2swFE3,
Lm2=Lm2swFE3, ROM=ROMswFE3, NZ=NZswFE3, NZromR=NZromRswFE3,
AREA=AREAswFE3, HA=HAswFE3, H=HswFE3, UK=UKswFE3, LK=LKswFE3, K=KswFE3);
      /*swFE p-value*/
      %Ptable(TAB=PswFE3nR, Eff=EffectSW, Ua1=Ua1swFE3nR, Um1=Um1swFE3nR,
Ua2=Ua2swFE3nR, Um2=Um2swFE3nR, La1=La1swFE3nR, Lm1=Lm1swFE3nR,
La2=La2swFE3nR, Lm2=Lm2swFE3nR, ROM=ROMswFE3nR, NZ=NZswFE3nR,
NZromR=NZromRswFE3nR, AREA=AREAswFE3nR, HA=HAswFE3nR, H=HswFE3nR,
UK=UKswFE3nR, LK=LKswFE3nR, K=KswFE3nR);/*swFE Rate-norm p-value*/
      %Ptable(TAB=PswFE3nT, Eff=EffectSW, Ua1=Ua1swFE3nT, Um1=Um1swFE3nT,
Ua2=Ua2swFE3nT, Um2=Um2swFE3nT, La1=La1swFE3nT, Lm1=Lm1swFE3nT,
La2=La2swFE3nT, Lm2=Lm2swFE3nT, ROM=ROMswFE3nT, NZ=NZswFE3nT,
NZromR=NZromRswFE3nT, AREA=AREAswFE3nT, HA=HAswFE3nT, H=HswFE3nT,
UK=UKswFE3nT, LK=LKswFE3nT, K=KswFE3nT);/*swFE Temp-norm p-value*/

      quit; /*proc datasets*/

options orientation=portrait; /*page formatting*/ /*options ls=78 pageno=1 */
ods pdf file="&Path\Report_Ptables.pdf";  /*initialize pdf output*/

      /*Report p-value Tables*/
      %macro RepP(Ptable=, Ptitle=, w1=, w2=, w3=, w4=);
            title2 "&Ptitle";
            footnote "Statistically Significant: #=p<0.0001 *=p<&SS
NS=p>&SS";

            proc report data=&Ptable nowd headline headskip;
                  column Effect Ua1 Um1 Ua2 Um2 La1 Lm1 La2 Lm2 ROM;
                  where Effect=&w1 or Effect=&w2 or Effect=&w3 or Effect=&w4;
                  define Ua1/center format=pFMT.;
                  define Um1/center format=pFMT.;
                  define Ua2/center format=pFMT.;
                  define Um2/center format=pFMT.;
                  define La1/center format=pFMT.;
                  define Lm1/center format=pFMT.;
                  define La2/center format=pFMT.;
                  define Lm2/center format=pFMT.;
                  define ROM/center format=pFMT.;
                  title3 "DIP-Boltzmann Paramaters";
            run;

            proc report data=&Ptable nowd headline headskip;
                  column Effect ROM AREA NZ NZromR HA H UK LK K;
                  where Effect=&w1 or Effect=&w2 or Effect=&w3 or Effect=&w4;
                  define ROM/center format=pFMT.;
                  define AREA/center format=pFMT.;
                  define NZ/center format=pFMT.;
                  define NZromR/center format=pFMT.;
                  define HA/center format=pFMT.;
                  define H/center format=pFMT.;
                  define UK/center format=pFMT.;
                  define LK/center format=pFMT.;
                  define K/center format=pFMT.;
                  title3 "Torque-Rotation Metrics";
            run;
```

```
      %mend RepP;
      %RepP(Ptable=Pdlp3, Ptitle=DLP p-Values, w1='Rate', w2='Temp',
w3='FSU', w4='Dir'); /*DLP p-values*/
      %RepP(Ptable=Pdlp3nR, Ptitle=DLP Rate-norm p-Values, w1='Rate', w2='X',
w3='FSU', w4='Dir'); /*DLPnorm p-values*/
      %RepP(Ptable=Pdlp3nT, Ptitle=DLP Temp-norm p-Values, w1='Rate', w2='X',
w3='FSU', w4='Dir'); /*DLPnorm p-values*/

      %RepP(Ptable=PswFE3, Ptitle=swFE p-Values, w1='Rate', w2='Temp',
w3='FSU', w4=''); /*swFE p-values*/
      %RepP(Ptable=PswFE3nR, Ptitle=swFE Rate-Norm p-Values, w1='Rate',
w2='', w3='FSU', w4=''); /*swFEnorm p-values*/
      %RepP(Ptable=PswFE3nT, Ptitle=swFE Rate-Norm p-Values, w1='Rate',
w2='', w3='FSU', w4=''); /*swFEnorm p-values*/


ods pdf close;    /*close pdf output*/
goptions reset=footnote;

/*Organize Predicted DataSets*/

/*===================================================================
===================================================================*/
proc sort data=ROMdlpLSnR;
      by Rate Temp;
run;

proc sort data=ROMswfeLSnR;
      by Rate Temp;
run;

      /*Rate-Normalized Proportionality Constants in Estimate(Error) form*/
      data PrRrep(drop=asFE); /*For reporting*/
            *length Rate $8;
            *format Rate $char8.;
            merge romDLPlsNR(rename=(Estimate=EstFE StdErr=errFE))
romSWfeLSnr(rename=(Estimate=EstFE StdErr=errFE));
            by Rate Temp;
            asFE = cat(put(EstFE,5.3), ' (', put(errFE,5.3), ')');
            select(Temp);
                  when ('BODY') BODYasFE=asFE;
                  when ('ROOM') ROOMasFE=asFE;
                  otherwise;
            end;
            *if Rate=1 then delete;
      run;

      data prR(drop=EstFE); /*For further calculations*/
            format DIR $char2.;
            set PrRrep(keep=Rate Temp EstFE);
            if Rate=0 then delete; /*Stepwise loading is unpredictable*/
                  do DIR='FE';
                  select (DIR);
                        when ('FE') prROM=EstFE;
                        otherwise;
                        end;
                        output;
```

```
            end;
    run;

    data PrRrepB(drop=Temp EstFE ErrFE ROOMasFE);
          set PrRrep;
          where Temp='BODY';
    run;

    data PrRrepR(drop=Temp EstFE ErrFE BODYasFE);
          set PrRrep;
          where Temp='ROOM';
    run;

    data PrRrep;
          merge PrRrepB PrRrepR;
          by Rate;
    run;

    proc sort data=prR;
          by Dir Temp Rate;
    run;

    proc sort data=FE;
          by Dir Temp Rate FSU ROM;
    run;

    data BArate(rename=(Rate=tRate));
          merge FE(keep=Dir Temp Rate FSU ROM Ua1 Um1 Ua2 Um2 La1 Lm1 La2
Lm2) prR(rename=(prROM=Ctest));
          by Dir Temp Rate;
          do dRate = .25, .5, 1, 2, 4, 6, 8, 10, 12, 14; /*Stepwise loading
is unpredictable*/
                output;
          end;
    run;

    proc sort data=BArate;
          by Dir Temp dRate FSU;
    run;

    data BArate (keep=Dir Temp FSU dRate estROM Ua1 Um1 Ua2 Um2 La1 Lm1 La2
Lm2 rename=(dRate=Rate)) /*(keep=Dir Temp FSU tRate dRate estROM)*/;
          merge BArate PrR(rename=(prROM=Cdesired Rate=dRate));
          by Dir Temp dRate;
          estROM = ROM*Cdesired/Ctest;
    run;

    proc sort data=BArate;
          by Dir Temp FSU Rate EstROM;
    run;

    proc sort data=FE;
          by Dir Temp FSU Rate;
    run;

    data BArate(drop=UAREA LAREA);
```

```
            merge FE(keep=Dir Temp Rate FSU ROM AREA NZ NZromR HA H UK
LK K) BArate;
            by Dir Temp FSU Rate;
            if ROM=. or AREA=. or NZ=. or NZromR=. or HA=. or H=. or K=. or
estROM=. then delete;
            if estROM=. then delete;
            UA = -estROM/2;
            UB = estROM/2;
            LA = UA;
            LB = UB;
            UAREA = UA*(&Tmax-&Tmin) - UA/UA1*log((1+exp(UA1*(&Tmax-
Um1)))/(1+exp(UA1*(&Tmin-Um1)))) + UB/UA2*log((1+exp(UA2*(&Tmax-
Um2)))/(1+exp(UA2*(&Tmin-Um2))));
            LAREA = LA*(&Tmax-&Tmin) - LA/LA1*log((1+exp(LA1*(&Tmax-
Lm1)))/(1+exp(LA1*(&Tmin-Lm1)))) + LB/LA2*log((1+exp(LA2*(&Tmax-
Lm2)))/(1+exp(LA2*(&Tmin-Lm2))));
            estAREA = UAREA - LAREA;
            estHA = estAREA/estROM;
      run;

      proc sort data=BArate;
            by Dir Temp FSU Rate ROM;
      run;

      /*Discrete rotation calculation of upper and lower DIP-Boltzmann
curves*/
      data BArateNZkh;
            set BArate;
            do m = &Tmin to &Tmax by &Tstep;
                  Utheta = UA/(1+exp(Ua1*(m-Um1))) - UB/(1+exp(Ua2*(m-Um2)))
+ UB; /*thetaUP*/
                  Ltheta = LA/(1+exp(La1*(m-Lm1))) - LB/(1+exp(La2*(m-Lm2)))
+ LB; /*thetaLOW*/
                  Dtheta = Utheta - Ltheta;
                  output;
            end;
      run;

proc sort data=BArateNZkh;
      by Dir Temp FSU Rate estROM;
run;

      proc means data=BArateNZkh max noprint;
            var Dtheta;
            by Dir Temp FSU Rate estROM;
            output out=BArateNZ(drop=_TYPE_ _FREQ_)
                  max=estNZ;
      run;

      /*Attach NZ to NZkh dataset */
      /*Set limit for calculating K and H, based on NZ*/
      /*Calculate derivative of upper and lower curves within a% of NZ*/
      data BArateNZkh (keep=Dir Temp FSU Rate ROM estROM estNZ mUP mLOW estUK
estLK);
            merge BArateNZkh BArateNZ;
            by Dir Temp FSU Rate estROM;
```

```
			/*To get NZ flexibility coefficient, determine the slope of 
the torque-rotation curve at rotation=0*/
			if Utheta>-&NZpercent*estNZ/2 and Utheta<&NZpercent*estNZ/2 
then
				do;
					Uf=-UA*Ua1*exp(Ua1*(m-Um1))/(1+exp(Ua1*(m-Um1)))**2 + 
UB*Ua2*exp(Ua2*(m-Um2))/(1+exp(Ua2*(m-Um2)))**2;
					estUK=1/Uf; /* [Stiffness] = 1/[Flexibility] */
					mUP = m;
				end;
			if Ltheta>-&NZpercent*estNZ/2 and Ltheta<&NZpercent*estNZ/2 then
				do;
					Lf=-LA*La1*exp(La1*(m-Lm1))/(1+exp(La1*(m-Lm1)))**2 + 
LB*La2*exp(La2*(m-Lm2))/(1+exp(La2*(m-Lm2)))**2;
					estLK=1/Lf; /* [Stiffness] = 1/[Flexibility] */
					mLOW = m;
				end;
	run;

	proc sort data=BArateNZkh;
		by Dir Temp FSU Rate estROM estNZ;
	run;

	/*Select UK, LK, mUP, and mLOW for each test subject (FSU+TEMP+DIR)*/
	proc means data=BArateNZkh mean noprint;
		var estUK estLK mUP mLOW;
		by Dir Temp FSU Rate estROM estNZ; /*want Dtheta, UK, LK for each 
obs*/
		output out=BArateNZkh(drop=_TYPE_ _FREQ_)
			mean=estUK estLK estMup estMlow;
	run;

	/*Attach NZ UK LK to raw dataset*/
	data BArate(drop=UA UB LA LB Ua1 Ua2 Um1 Um2 La1 La2 Lm1 Lm2 estMlow 
estMup);
		merge BArate BArateNZkh;
		by Dir Temp FSU Rate;
		estK=mean(estUK,estLK);
		estH=estMlow-estMup;
		estNZROMr=estNZ/estROM; /*NZ-to-ROM ratio*/
		if estH=. then delete;
	run;

	proc sort data=BArate;
		by Dir Temp FSU Rate;
	run;
	proc sort data=BArateNZkh;
		by Dir Temp FSU Rate;
	run;

/*begin calculation of R-squared value (the coefficient of determination*/
	proc means data=BArate noprint mean;
		var ROM AREA NZ NZromR HA H UK LK K;
		by Dir;
		output out=R2rate(drop=_TYPE_ _FREQ_)
			mean=ROMmean AREAmean NZmean NZromRmean HAmean Hmean UKmean 
LKmean Kmean;
```

```
      run;

      data R2rate(keep=Dir ROMse AREAse NZse NZromRse HAse Hse UKse
LKse Kse ROMst AREAst NZst NZromRst HAst Hst UKst LKst Kst);
            merge BArate(keep=Dir ROM AREA NZ NZromR HA H UK LK K estROM
estAREA estNZ estNZromR estHA estH estUK estLK estK) R2rate;
            by Dir;
            ROMse = (ROM-estROM)**2;
            AREAse = (AREA-estAREA)**2;
            NZse = (NZ-estNZ)**2;
            NZromRse = (NZromR-estNZromR)**2;
            HAse = (HA-estHA)**2;
            Hse = (H-estH)**2;
            UKse = (UK-estUK)**2;
            LKse = (LK-estLK)**2;
            Kse = (K-estK)**2;
            ROMst = (ROM-ROMmean)**2;
            AREAst = (AREA-AREAmean)**2;
            NZst = (NZ-NZmean)**2;
            NZromRst = (NZromR-NZromRmean)**2;
            HAst = (HA-HAmean)**2;
            Hst = (H-Hmean)**2;
            UKst = (UK-UKmean)**2;
            LKst = (LK-LKmean)**2;
            Kst = (K-Kmean)**2;
      run;

      proc means data=R2rate noprint sum;
            var ROMse AREAse NZse NZromRse HAse Hse UKse LKse Kse ROMst
AREAst NZst NZromRst HAst Hst UKst LKst Kst;
            by Dir;
            output out=R2rate(drop=_TYPE_ _FREQ_)
                  sum=ROMse AREAse NZse NZromRse HAse Hse UKse LKse Kse ROMst
AREAst NZst NZromRst HAst Hst UKst LKst Kst;
      run;

      data R2rate(keep=r2ROMfe r2AREAfe r2NZfe r2NZromRfe r2HAfe r2Hfe r2UKfe
r2LKfe r2Kfe);
            set R2rate;
            if Dir='AR' then
                  do;
                        r2ROMar=1-ROMse/ROMst;
                              call symput("r2ROMLar", putn(r2ROMar, 5.3));
                        r2AREAar=1-AREAse/AREAst;
                              call symput("r2AREALar", putn(r2AREAar, 5.3));
                        r2NZar=1-NZse/NZst;
                              call symput("r2NZLar", putn(r2NZar, 5.3));
                        r2NZromRar=1-NZromRse/NZromRst;
                              call symput("r2NZromRLar", putn(r2NZromRar,
5.3));
                        r2HAar=1-HAse/HAst;
                              call symput("r2HALar", putn(r2HAar, 5.3));
                        r2Har=1-Hse/Hst;
                              call symput("r2HLar", putn(r2Har, 5.3));
                        r2UKar=1-UKse/UKst;
                              call symput("r2UKLar", putn(r2UKar, 5.3));
                        r2LKar=1-LKse/LKst;
```

```
                              call symput("r2LKLar", putn(r2LKar,
5.3));
                        r2Kar=1-Kse/Kst;
                              call symput("r2KLar", putn(r2Kar, 5.3));
                  end;
            else if Dir='FE' then
                  do;
                        r2ROMfe=1-ROMse/ROMst;
                              call symput("r2ROMLfe", putn(r2ROMfe, 5.3));
                        r2AREAfe=1-AREAse/AREAst;
                              call symput("r2AREALfe", putn(r2AREAfe, 5.3));
                        r2NZfe=1-NZse/NZst;
                              call symput("r2NZLfe", putn(r2NZfe, 5.3));
                        r2NZromRfe=1-NZromRse/NZromRst;
                              call symput("r2NZromRLfe", putn(r2NZromRfe,
5.3));
                        r2HAfe=1-HAse/HAst;
                              call symput("r2HALfe", putn(r2HAfe, 5.3));
                        r2Hfe=1-Hse/Hst;
                              call symput("r2HLfe", putn(r2Hfe, 5.3));
                        r2UKfe=1-UKse/UKst;
                              call symput("r2UKLfe", putn(r2UKfe, 5.3));
                        r2LKfe=1-LKse/LKst;
                              call symput("r2LKLfe", putn(r2LKfe, 5.3));
                        r2Kfe=1-Kse/Kst;
                              call symput("r2KLfe", putn(r2Kfe, 5.3));
                  end;
            else if Dir='LB' then
                  do;
                        r2ROMlb=1-ROMse/ROMst;
                              call symput("r2ROMLlb", putn(r2ROMlb, 5.3));
                        r2AREAlb=1-AREAse/AREAst;
                              call symput("r2AREALlb", putn(r2AREAlb, 5.3));
                        r2NZlb=1-NZse/NZst;
                              call symput("r2NZLlb", putn(r2NZlb, 5.3));
                        r2NZromRlb=1-NZromRse/NZromRst;
                              call symput("r2NZromRLlb", putn(r2NZromRlb,
5.3));
                        r2HAlb=1-HAse/HAst;
                              call symput("r2HALlb", putn(r2HAlb, 5.3));
                        r2Hlb=1-Hse/Hst;
                              call symput("r2HLlb", putn(r2Hlb, 5.3));
                        r2UKlb=1-UKse/UKst;
                              call symput("r2UKLlb", putn(r2UKlb, 5.3));
                        r2LKlb=1-LKse/LKst;
                              call symput("r2LKLlb", putn(r2LKlb, 5.3));
                        r2Klb=1-Kse/Kst;
                              call symput("r2KLlb", putn(r2Klb, 5.3));
                  end;
      run;

options orientation=landscape;
ods pdf file="&Path\BlandAltman.pdf";     /*initialize pdf output*/

/*Report ROM Prediction Tables*/
/*====================================================================*/
```

```
      proc report data=PrRrep nowd headline headskip;
            columns Rate BODYasFE ROOMasFE;
            define Rate/display "Rate" center;
            define BODYasFE/center "Body/Temperature" width=14;
            define ROOMasFE/center "Room/Temperature" width=14;
            title2 "Effect of Follower Rate";
            title3 "noRate/Rate";
      run;

/*Create Bland-Altman Plots*/
/*======================================================================*/
%macro Bland(BA=, estBA=, BAset=, baTITLE=, EST=, minx=, maxx=, tickx=,
ticky=, footFE=);
/*Bland-Altman Analysis of Predicted Datasets*/
      data &BA;
            set &BAset(keep=FSU Temp Rate Dir &BA &estBA);
            diff=&estBA-&BA;
            avg=(&estBA+&BA)/2;
      run;

      data anno;
            function='move'; xsys='1';ysys='1'; x=0; y=0; output;
            function='draw'; xsys='1';ysys='1'; color='green'; x=100; y=100;
size=2; output;
      run;

      data prelim;set &BA;
            proc means noprint data=prelim; var diff;
            output out=diff mean=meandiff std=stddiff;
      run;

      data perf;set prelim;
            if _N_=1 then set diff;
            ubound=meandiff+stddiff*2;
            lbound=meandiff-stddiff*2;
                  /*store in macro variables*/
                  call symput('bupper',ubound);
                  call symput('blower',lbound);
                  call symput('bmeandiff',meandiff);
      run;

            symbol1 i=none v=dot c=red height=1;
            symbol2 i=none v=dot c=blue height=1;

      /*Bland-Altman Analysis Identity Plot*/
            proc gplot data=&BA;
                  plot &BA*&estBA=Temp / anno=anno haxis=axis1 vaxis=axis2;
                  * X AXIS - HORIZONTAL;
                        axis1 /*length=5.5 in width=1 */
                        label=(f="Arial" h=3 "Predicted &BA")
                        value=(font="Arial" h=3)
                        order=&minx to &maxx by &tickx;
             * YAXIS - VERTICAL;
                        axis2 /*length=4.5 in width=1*/
                        label=(f="Arial" h=3 angle=90 "Actual &BA")
                        value=(font="Arial" h=3)
                        order=&minx to &maxx by &ticky;
```

```
                footnote "[R-squared]: FE=&footFE";
                title2 h=2 f="Arial" "Identity Plot - &BA";
                title3 "Actual vs Predicted: &EST";
          run; quit;

      proc gplot data=&BA;
          plot diff*avg=Temp / vref= (&blower &bupper &bmeandiff)
                cvref=red haxis=axis1 vaxis=axis2;
             * XAXIS - HORIZONTAL - AVERAGE;
                axis1 /*length=6.5 in width=1*/
                      label=(f="Arial" h=3 "Mean &BA")
                      value=(font="Arial" h=3);
             * YAXIS - Vertical - Difference;
                axis2 /*length=4.5 in width=1*/
                      label=(f="Arial" h=3 angle=90 'Error')
                      value=(font="Arial" h=3);
                *footnote h=1 f="Arial" "Bland-Altman Plot";
                title2 h=2 f="Arial" "Bland-Altman Analysis - &BA";
                title3 "Error vs Mean: &EST";
          run; quit;

%mend Bland;
%Bland(BA=ROM, estBA=estROM, BAset=BArate, baTITLE=ROM Rate Constants,
EST=Rate, minx=0, maxx=24, tickx=4, ticky=4, footFE=&r2ROMLfe);
%Bland(BA=AREA, estBA=estAREA, BAset=BArate, baTITLE=AREA Rate Constants,
EST=Rate, minx=0, maxx=24, tickx=4, ticky=4, footFE=&r2AREALfe);
%Bland(BA=NZ, estBA=estNZ, BAset=BArate, baTITLE=NZ Rate Constants, EST=Rate,
minx=0, maxx=15, tickx=3, ticky=3, footFE=&r2NZLfe);
%Bland(BA=NZromR, estBA=estNZromR, BAset=BArate, baTITLE=NZromR Rate
Constants, EST=Rate, minx=0, maxx=3, tickx=.25, ticky=.25,
footFE=&r2NZromRLfe);
%Bland(BA=HA, estBA=estHA, BAset=BArate, baTITLE=HA Rate Constants, EST=Rate,
minx=0, maxx=3.5, tickx=1, ticky=1, footFE=&r2HALfe);
%Bland(BA=H, estBA=estH, BAset=BArate, baTITLE=H Rate Constants, EST=Rate,
minx=0, maxx=3.5, tickx=1, ticky=1, footFE=&r2HLfe);
%Bland(BA=UK, estBA=estUK, BAset=BArate, baTITLE=UK Rate Constants, EST=Rate,
minx=0, maxx=5, tickx=1, ticky=1, footFE=&r2UKLfe);
%Bland(BA=LK, estBA=estLK, BAset=BArate, baTITLE=LK Rate Constants, EST=Rate,
minx=0, maxx=5, tickx=1, ticky=1, footFE=&r2LKLfe);
%Bland(BA=K, estBA=estK, BAset=BArate, baTITLE=K Rate Constants, EST=Rate,
minx=0, maxx=5, tickx=1, ticky=1, footFE=&r2KLfe);
ods pdf close;     /*close pdf output*/
ods rtf close;     /*close rtf output*/
ods html close;    /*close html output*/
```