

## 1.01 FOUNDATION VARIABLE SPEED CONTROL SYSTEM

### A. GENERAL

1. The entire motor system shall be operated by an Electronic Theatre Controls (ETC) Foundation rigging control system. It shall be purpose-designed and fabricated to manage and operate motors specifically designed for overhead lifting. The System shall incorporate mechanical, electrical and safety features that shall be inherent to this equipment and shall provide an engineered, efficient device to control the equipment. The mechanical, electrical and safety features of this control system shall establish the standard of quality, performance and safety by which motor systems of other manufacture shall be evaluated. The controller shall be capable to control up to 48 motors. The controller shall provide two connections for motor communication, supplying up to 24 motors per connection
2. The Foundation control system shall consist of a surface or panel mounted primary controller and up to six optional external E-stop stations
3. The controller shall be UL Listed and shall be fabricated from UL Listed components
4. The Emergency Stop and Hold-To-Run (Dead-man) signals between the control station and the motor starters or drives in the motors shall be hard wired 24 Volt signals
5. Systems that rely on software and bus communications to transmit any of these signals shall not be acceptable
6. Only physical, industrial heavy duty pushbuttons shall create a "dead-man" Signal. The "dead-man" operation is required, so that the operator must be at the console and pressing a button to initiate and continue motion
7. For safety, no movement shall be permitted to be initiated from the touch screen
8. Systems that allow motors to run without an operator actively present at the console shall not be permitted
9. The system shall not contain any permanently moving components (like hard drives or fans) and shall be maintenance free and completely quiet during operation
10. The control system shall only employ the FOUNDATION controller, a power and control distribution infrastructure and the motors. A System that requires separate drive cabinets or motor-starters shall not be acceptable

### B. ENCLOSURE

1. The side panels of the control system shall be machined out of solid Aluminum. The thickness shall be no less than ¼"
2. The wall mount bracket and face panel shall be fabricated from 16ga powder coated sheet steel specially formed to provide support for the installation

3. The control section of the system shall be lockable by rotation of the entire surface. The system shall provide a physical lock, once it is in the closed position
4. An optional lockable cover shall be available
5. The Foundation face panel shall be printed with complete labeling information to identify the function of each of the buttons in the control station
6. The face panel shall identify the system as a Foundation controller for stage rigging
7. The wall mount bracket shall be mountable independently from the control station. It shall be possible to run in and terminate all wires on connectors just with the installed wall bracket
8. The entire control panel shall be easy to connect to the wall bracket. All electrical connections shall be made via touch safe connectors. The system shall be closed up by concealed screws
9. A system that relies on directly terminated / non-connectorized building wires to the control system shall not be acceptable. The Foundation controller shall run on 100V to 240V AC 50/60Hz, 2A max Power

#### C. BUTTONS AND JOYSTICK

1. The control system shall include one power button with a power indication LED
2. The control system shall include one readily accessible USB port for the connection of a USB memory stick for the use with show file transfer, inspection reports, log files and software updates
3. The control system shall include two illuminated and dimmable "GO" buttons
4. The control system shall include one proportional joystick
  - a. The position sensing shall be done by an absolute hall effect encoder
  - b. Joysticks that rely on analog pots or incremental encoders shall not be acceptable
  - c. The joystick shall incorporate one dead man button
  - d. The joystick shall incorporate 2 RGB LED illuminated and dimmable indication areas that allow indication of the direction, function or status of the Joystick

#### D. E-STOP

1. The E-stop button on the FOUNDATION controller shall be an NFPA-79 compliant mushroom head button with an illuminated ring surrounding the button
2. During normal operation the E-stop button shall be in the out position. An E-stop can be activated via this button by firmly pressing the button in. The button shall latch and immediately cause all motors in the system to stop motion

3. To continue system operation the E-stop button must be cleared at the station where it was pressed by twisting the button to release the latch. The E-stop must be acknowledged at the control station where it was activated before any new movement can occur
4. The operator shall acknowledge the end of an E-stop condition. At that time the control system shall initiate an automatic self-test of the system safety functions including safe opening of all E-stop contactors
5. The illuminated ring around the E-stop button shall change intensity depending on whether the system is moving or not. The transition between low and high intensity shall be a smooth fade. The intensity levels shall be adjustable at the time of installation or service
6. The illuminated ring around the E-stop button shall blink in case of an E-stop condition
7. In addition to the E-stop station at the main control panel, up to six external E-stop stations may be connected to the system. Each external E-stop station shall operate in the same way as the primary E-stop at the FOUNDATION control panel
8. The LCD screen shall report the E-stop as an E-stop condition
9. The report shall indicate if the activated E-stop was the internal one, the one on the remote control or one of the external stations
10. The E-stop system shall be completely hard-wired. A system that relies on software or bus system to transmit E-stop signals shall not be acceptable for this installation
11. The E-stop signal shall be provided in parallel to all E-stop contactors in the motors. A single E-stop contactor failure shall only affect a single motor
12. Serial wiring of the E-Stop signal from motor to motor shall not be acceptable

E. LCD SCREEN

1. The graphic LCD screen shall be a 15" full industrial grade graphics type to communicate all information in symbols, colors and human readable text
2. The display shall be illuminated
3. The FOUNDATION control system shall employ an ambient light sensor and proximity sensor
4. All intensities of all indicator lights and LCD intensity shall be dimmable and shall automatically adjust based on ambient light conditions. Intensity changes shall be happen in smooth slow fades
5. If the control system is not used for a pre-determined time, the intensities shall dim further down. If the proximity sensor is actuated, the intensities shall dim up again

6. The screen shall employ a multi-touch sensor that allows for gesture control like zooming and scrolling
7. Readout language may be selected to be English, Spanish, French or German
8. It shall be possible to look at all motors or only a sub set, based on a flexi-channel filter

#### F. USER ACCESS LEVELS

1. Upon completion of the startup sequence the display shall indicate that the system is "OK" or shall provide specific information should a fault occur in the self-test
2. Fault conditions shall be reported in human readable text. Any system that reports fault conditions in a pattern of illuminated lights or a series of blinking lights shall not be acceptable for this installation
3. The FOUNDATION system shall provide at least the following access levels
  - a. Emergency User
  - b. User
  - c. Power User
  - d. Administrator
  - e. Commissioning
  - f. Inspection
4. These levels shall be unlocked either by a user name and pin code or via a USB dongle
5. It shall be possible to call the manufacturer to retrieve a 3-day temporary access code for any access level for the specific control system

#### G. OPERATION

1. The LCD screen shall provide a display of the motor name and number, its current position above the floor, the amount of weight suspended from the batten, preset position recorded, as well as a bar graph scale that shows the current position of the motor and the current weight suspended by the motor
2. Fault conditions shall be displayed in red or orange, depending on the severity of the condition
3. Position readout and position entry shall be in feet and inches, in decimal feet or in metric dimensions
4. The weight readout shall be in pounds or kilograms

#### H. MANUAL OPERATION

1. In manual operation, it shall be possible to select one or multiple motors and then directly move the selected motors by the means of the joystick

2. The user shall have the ability to change the name of a motor
3. The user shall have the ability to add a comment for each motor
4. The user shall have the ability to store the following trims
  - a. High trim (soft upper limit)
  - b. Low trim (soft lower limit)
  - c. 8 intermediate trims
  - d. 2 system wide trims
5. These trims shall be usable as references in presets and cues
6. The user shall have the ability to directly enter a numeric target position

I. PRESET OPERATION

1. The system shall provide the capability to store presets with numbers ranging from 1 to 999.
2. The user shall be able to add individual motors with specific positions to presets
3. The user shall be able to name each preset
4. The user shall be able to add a comment to each preset

J. CUE STACK OPERATION

1. The system shall provide the capability to store cues with numbers ranging from 1.00 to 999.99
2. The user shall be able to add individual motors with specific positions to cues
3. The system shall be able to display multiple cues with their stored motors and positions at the same time in spreadsheet type view
4. For each cue, it shall be possible to assign:
  - a. One total move speed for all motors
  - b. Different move speeds and wait times for all up- and downwards moving motors
  - c. Individual move speeds and wait times for each motor in the cue
  - d. One total move time for all motors
  - e. Different move and wait times for all up- and downwards moving motors.
  - f. Individual move and wait times for each motor in the cue
5. It shall be possible to enter a cue playback rate that re-calculates the times or speeds of the cue
6. In playback, it shall be possible to start a selected cue with either one of the two "GO" buttons

7. During playback, it shall be possible to override the playback speed with the joystick. The joystick shall indicate this function via a specific color code
8. On completion of a cue, the next cue shall automatically be loaded
9. It shall be possible to start the next cue(s) while the current cue is still running
10. The control system shall display the current cue and additionally several cues and the respective motors, targets, speeds and speeds in a spreadsheet pattern
11. The control system shall display the remaining time of a running cue

K. FILE OPERATION

1. The control system shall provide the means of storing at least 10,000 different show-files on the internal hard-drive
2. The control system shall provide a means to store and read show-files to/from a USB thumb drive

L. HELP SYSTEM

1. The control system shall provide an online help system embedded in the console

M. FIXED SPEED REMOTE CONTROL PENDANT

1. An optional remote control pendant with a 30'-0" long attached cable and plug shall be provided for the system. The remote control shall connect to the FOUNDATION control system via a connector on a 2-gang wall-plate
2. The remote control pendant shall provide an up, down and E-Stop button
3. The remote control shall provide up/down control for those motors that have been selected at the FOUNDATION controller
4. When the remote control is plugged in the E-stop on the remote control shall be activated
5. When the remote control is unplugged, the E-Stop system shall seamlessly and automatically bypass the connector. This bypass system shall be achieved by a redundant means and shall be monitored and frequently tested for proper functionality
6. A "shunt-plug" to achieve this function shall not be acceptable

N. REMOTE ENABLE PENDANT

1. An optional remote enable pendant with a 30'-0" long attached cable and plug shall be provided for the system. The remote control shall connect to the FOUNDATION control system via a connector on a 2-gang wall-plate
2. The remote enable pendant shall provide an enable and an E-Stop button
3. The connector shall be the same as for the remote control and the same E-Stop bypass principles shall apply

O. FOUNDATION HANDHELD REMOTE

1. An optional Foundation remote control unit with a 50'-0" long attached cable and plug shall be provided for the system. The remote control unit shall connect to the Foundation control system via a connector on a plug-in station
2. The remote control unit shall be ergonomically designed to be held with either hand and operated with the other hand
  - a. The length of the remote control unit, including grip, shall not exceed 13" and the width shall not exceed 7.85"
  - b. The weight of the remote control unit shall not exceed 10 lbs
  - c. The remote control unit shall support two ¼-20 D-rings (not included) for attaching an optional strap (not included)
  - d. An optional wall mounted storage bracket shall be available (not included)
3. The screen shall be a full color 7" touch screen, with a resolution of 640x480 pixels.
4. The unit shall be supplied with 30 Vdc and shall communicate by Ethernet and by hardwired 24V signals for E-Stop and Dead-Man
5. An E-Stop button shall be provided on the front of the unit
6. Proportional Joystick
  - a. A proportional joystick shall be provided on the remote control unit
    - 1) The user shall be able to manually move motors up and down with this joystick
    - 2) The user shall be able to proportionally control the motor movement speed during target moves or cues with this joystick
7. User function
  - a. The remote control unit shall be accessible with multiple access levels that are configured on the Foundation control system
  - b. The user shall be able to see on a simultaneous overview of all motors in the system with status, position and load information
  - c. The user shall be able to see the system time and the loaded show on the screen
  - d. The user shall be able to select one or several motors from the touch screen
  - e. The user shall be able to manually move one or multiple motors up and down with the joystick
  - f. The user shall be able to enter a target position for a motor and move that motor to this target position
  - g. The user shall be able to store up to 8 user trims and two user limits for each motor
  - h. The user shall be able to see detailed status information of a selected motor

- i. The user shall be able to recall presets and move associated motors to positions stored in these presets
  - j. The user shall be able to recall cues from the cue stack and start these cues
8. The remote control unit shall provide a hard-wired dead man trigger
9. Connection box
- a. The remote control connection box shall be manufactured from solid sheet metal.
  - b. The remote control connection box shall provide a power switch with a power status LED built in.
  - c. The remote control connection box shall provide a high and a low voltage wiring chamber, separated by a grounded metal divider
  - d. The remote control connection box shall provide a power supply for the remote control
  - e. The remote control connection box shall provide a field Ethernet wire punch down termination means.
  - f. The remote control connection box shall provide termination means for the hard-wired dead man and E-Stop circuits

P. SYSTEM DIAGNOSTICS

- 1. Upon energization of the control system shall automatically perform a series of diagnostic tests that assures the proper functionality of all system safety functions. Should an error in the safety functions be determined, the controller shall report back a fault condition on the LCD display and shall identify the nature of the fault in human readable text form
- 2. Should the controller be continuously energized, the system shall automatically perform a series of diagnostic tests every 30 days to determine if there are any problems with any portion of the motor control system safety features. In the event of a problem, the controller shall report back a fault condition on the LCD display and shall identify the nature of the fault in readable text form
- 3. The automatic self-tests shall include a complete test of all Emergency Stop contactors for their respective ability to turn off
- 4. Eleven months after a system inspection has been performed, the system shall remind the user to schedule a full system maintenance/inspection. The reminder shall remain visible in the system until it is turned off by the factory authorized and trained inspector
- 5. All faults and failures shall be displayed on the control station as a color indication of the respective motor and additionally as clear text
- 6. The system inspection reminder shall show the number of days remaining until the system inspection, or the number of days the inspection is overdue
- 7. A failure of the Load Cell, Encoders or a wiring issue shall be automatically detected during machine standstill and motion

8. Motor, brake resistor or drive over-temperature shall be detected and shall stop the motor
9. The motor direction shall be detected and the system shall automatically be stopped if the command direction differs from the actual movement direction
10. A failure of the chain between the drum and the limits shall create a fault condition and stop the motor
11. The number of simultaneous moving motors shall be limited in the control system in order to reduce the maximum dynamic load to the building structure
  - a. The system shall trip out the control system if more than the allowed amount of motors are about to start to move
  - b. This system shall react before the motors start to move to avoid even the initial startup load impact
  - c. The setting for this limit shall allow a granularity of 1 motor increment
  - d. This system shall be executed in pure hardware
  - e. This system shall have redundant software back up
  - f. Systems that solely rely on software to achieve this function shall not be acceptable

Q. MONITORING AND MOTOR HISTORY

1. The system shall automatically keep track of system and motor history
2. Each fault condition shall be logged with a time and date stamp. Logging of the motor events shall continue to function while the main control station is turned off or while the motor is not connected to the rest of the system
3. The control system shall keep a record of the distance traveled and peak load for each motor. There shall be separate entries of this data for "Since the last inspection" and "Since time of manufacture"
4. The data shall be accessible during inspection. It shall be downloadable in an Excel readable file format
5. A control system that does not provide logging shall not be acceptable

R. CONFIGURATION

1. The control system shall provide all configuration software "on-board"
2. It shall be possible to configure all motor functions through the control system at the control panel. A system that requires an additional computer or laptop connected to the motor or the system shall not be acceptable for this installation
3. The configuration software shall allow easy and simple configuration of the system by factory trained and authorized installers

S. INSPECTION

1. On-Board software shall allow easy and quick annual inspection of the control system functions by a factory trained and authorized inspector
  - a. The inspection software shall automatically provide inspection relevant data to the inspector, such as peak load and travel distance
  - b. The software shall guide the inspector through a number of inspection tasks
  - c. The software shall automatically recognize safety relevant signals (E-stop, Limit Switches)
2. The inspection software shall automatically fill in an inspection report and generate a PDF file that can be stored on a USB thumb-drive
3. The inspection report shall include a 2D barcode that encodes a copy of the inspection data and a checksum that can be utilized to validate the inspection report

## Part 2. INSTALLATION

### 2.01 GENERAL

- A. Installation of this equipment shall only be performed by ETC approved and factory trained theatrical rigging installers. Installation shall be performed in a workmanlike manner and shall strictly adhere to the standards of these specifications and ETC's installation requirements. Where necessary, the installer may make adjustments to accommodate unforeseen impediments to installation. The completed work must achieve all electrical, safety and appearance requirements as established in these specifications
- B. Work shall be performed in accordance with OSHA and local codes
- C. On site welding shall only be performed per AWS D1.1 standards and with advanced approval from the architect or Owner's representative
- D. DIVISION OF RESPONSIBILITIES
  1. The RIGGING contractor shall be responsible for providing and installing:
    - a. Powerhead
    - b. Compression Tube, Compression Tube splices and Compression Tube beam clamps
    - c. Supplementary steel and/or mounting adapters for the hoisting systems, if required
    - d. Loft blocks
    - e. Wire rope lift lines and terminations
    - f. On electrics line sets: Cable Management system for distribution raceways, including low-voltage, ground and data wiring
    - g. On electrics line sets: Factory prewired electrical termination boxes that are part of the cable management system
    - h. On electrics line sets: Factory prewired distribution raceway mounted at the bottom of the wire rope on the stage electrics sets

- i. Pipe batten attached to RACAs or Hanger Brackets
  - j. Batten end caps
  - k. Batten labels
  - l. Attachment of the prewired twist-lock connector to the Power and Control Distribution outlet
  - m. Attachment of the prewired circular pin connector data wire to the mating outlet on the Powerhead and on the Power and Control Distribution box
  - n. Termination of the low voltage data wiring at the controller and at all power and control distribution boxes and at each E-stop station
  - o. Face plates for all Control Stations, E-stop Stations and Power and Control Distribution Boxes
  - p. Set limit switches
2. The ELECTRICAL contractor shall be responsible for providing and installing:
- a. All pipe, wiring and termination providing line voltage to all the Power and Control Distribution boxes
  - b. All pipe and wiring connecting data lines between the first Power and Control Distribution Box and the Control station
  - c. Pipe and wiring connecting data lines between Control Station and first E-Stop Station
  - d. All pipe and wiring connecting data lines between all E-Stop Stations
  - e. Back boxes for all Power and Control Distribution Boxes, the Control Stations and all E-Stop Stations
  - f. All pipe and wiring and all terminations of line voltage of dimmed and non-dimmed circuits that terminate at the termination boxes mounted on/near the Compression Tube.

END OF SECTION