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SDSS Telescope Motion Interlock System Final Test Report

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The final installation of the motion control interlock system has been completed with the most recent changes allowing for motions inside the building. This document serves as the results of the completed tests, which were conducted December 11-13, 1999. The required performance specifications for the Telescope Motion Control Interlock System can be found in the document Technical Requirements and Performance Specifications for the 2.5-Meter Telescope, available on the web at http://tdpc01.fnal.gov/sdss/project.htm.

The system testing performed was accomplished by causing a known system violation and monitoring for the correct response. All test results reference the MCP encoder values converted to fractional degrees. There were several items that were unable to be tested. A list of these items and a brief discussion detailing the issues associated with the untested item follow the system test results.

The last section lists the required modifications to the completed system to fulfill the performance requirements including possible modifications as a result of the December 15, 1999 teleconference.

The following logic diagrams should be referenced for the complete interlock tests. The test table references the actual motion angular trip settings and does not reference each individual inhibit.

Rotator Motion Logic Diagram	3885.200-EB-355924	Rev. I
Altitude Motion Logic Diagram	3885.200-EB-355925	Rev. L
Azimuth Motion Logic Diagram	3885.200-EB-355926	Rev. I
Instrument Lift Motion Logic Diagram	3885.200-EB-355927	Rev. F
Instrument Latch Logic Diagram	3885.200-EB-355928	Rev. D
Brake & 15 Degree Stop Logic Diagram	3885.200-EB-355933	Rev. D
Flat Field Screen Control Logic Diagram	3885.200-EB-355937	Rev. C
Spectrograph Control Logic Diagram	3885.200-EB-355938	Rev. A
Building Motion Logic Diagram	3885.200-EB-355939	Rev. A

A short discussion on the rules for telescope motion is in order. Lets begin with the telescope at the stow position and the building on.

a) The altitude is allowed to move from 0.5 degrees to 19.5 degrees and azimuth is not allowed to move.

b) For altitude angles of 19.5 degrees up to 83.5 degrees, the telescope is allowed to move in azimuth from 111 to 131 degrees.
c) For altitude angles greater than 83.5 degrees, the telescope is allowed to move in azimuth from -170 to 407 degrees.

With the building off, beginning at the stow position the rules are:

a) The altitude is allowed to move from 0.5 degrees to 19.5 degrees and azimuth is not allowed to move.

b) For altitude angles greater than 19.5 degrees, the telescope is allowed to move in azimuth from -170 to 407 degrees.

Any motions outside the windows listed above will first assert a directional inhibit to the windbaffle and telescope amplifiers. If motion continues a second inhibit will drop power to the telescope and windbaffle amplifiers.

Prior to beginning testing, the altitude clinometer was calibrated to the MCP encoders. The slope points internal to the PLC are established as:

Clinometer	MCP
8499	2.13 degrees
-9536	89.93 degrees

E-Stop Tests
The following e-stop switches were tested to ensure the telescope and windbaffle Azimuth, Altitude, and Rotator amplifiers all trip off inhibiting any motions.

Control Room
TCC (currently not implemented from the TCC)
North Lower Level
South Lower Level
East Lower Level
West Lower Level
North Rail
South Rail
West Rail
North Windbaffle
North Fork
South Windbaffle

All e-stop switches functioned properly.

Altitude Tests

In the following section, a hard limit trip will drop out the Windbaffle and Telescope Altitude motors. A soft limit trip will assert a directional inhibit to the Windbaffle and Telescope Altitude servo amplifiers.

The altitude stow position is any angle below the stow position setting below. At present this simply lights a light indicating the telescope will clear the building door. When the remaining building work is complete, this limit will be used to inhibit building motion if the telescope is above the stow limit.

The 0.3 and 0.5 degree limits are active when the telescope is at the azimuth stow position only. These limits prevent the telescope from going below 0.0 degrees.

The 15.5 degree limit is used to prevent the telescope from contacting the 15 degree stop. This limit is active when stowing the telescope. If the 15 degree stop should not retract due to loss of air pressure or mechanical problems, a soft inhibit is asserted to prevent any damage to the stop from the Windbaffle.

The 19.0 and 19.5 degree limits prevent the telescope from contacting the hatch or safety rails. This limit is active with the building on and azimuth within 111 to 132 degrees with the exception of azimuth stow. The limit is also active with the building off at any azimuth angle except azimuth stow.

The 83.0 and 83.5 degree limits are active when the building is on and the azimuth rotation is outside the 111 to 132 degree range. This limit is used to prevent the telescope from contacting the sides of the building.

The 91.0 and 91.5 limits are used to prevent the telescope from going beyond its zenith limits. This limit is always active.

The 15 degree stop data shows the point where the 15 degree stop will extend and retract at. The stop will only retract at the azimuth stow position.

	Actual Trip Point
Stow Position	< 2.9 degrees
Down limits	
Azimuth in stow position	
0.3 degree hard limit trip	0.4 degrees
0.5 degree soft limit trip	0.5 degrees

15 degree stop extended

15.5 degree soft limit trip	15.4 degrees

Building off, not at stow.

19.0 degree hard limit trip	18.4 degrees
19.5 degree soft limit trip	19.5 degrees

Building On (azimuth > 110 and < 130, but not at azimuth stow)

83.0 degree hard limit trip	82.2 degrees
83.5 degree soft limit trip	83.3 degrees

Up Limits

91.5 degree hard limit trip	91.9 degrees
91.0 degree soft limit trip	91.0 degrees

15 degree stop

Extends at	17.0 degrees
Retracts at	16.4 degrees

Azimuth Tests

In the following section, a hard limit trip will drop out the Windbaffle and Telescope Azimuth motors. A soft limit trip will assert a directional inhibit to the Windbaffle and Telescope Azimuth servo amplifiers.

The azimuth stow position is any angle between the stow A and stow B position settings below. When inside the azimuth stow range, telescope altitude motion is allowed below the 19.5 degree limit down to the 0.5 degree limit. When the remaining building work is complete, this limit will be used to inhibit building motion if the telescope is outside the stow limit. The stow center switch is used to indicate the approximate center of stow A and stow B. This switch simply lights an indicator light to assist in operational efficiency.

The building clear or Altitude > 83.0 degrees limits allow for the maximum azimuth rotation. This limit is active when the building is off and the telescope is above the 19.5 degree limit or with the building on and the telescope above 83.0 degrees.

Stow A Position	120.8 degrees
Stow B Position	121.4 degrees
Stow Center Switch Position	121.0 degrees

Building Clear or Alt > 83 degrees

CCW hard limit trip	411.8 degrees
CCW soft limit trip	407.8 degrees
CW hard limit trip	-161.0 degrees
CW soft limit trip	-170.7 degrees

Building On altitude > 19.5 and < 83.3

CCW hard limit trip	132.1 degrees
CCW soft limit trip	131.0 degrees
CW hard limit trip	110.0 degrees
CW soft limit trip	111.0 degrees

Rotator Tests

In the following section, a hard limit trip will drop out the Telescope Rotator motor. A soft limit trip will assert a directional inhibit to the Telescope Rotator servo amplifiers.

The limits are always active and represent the maximum rotator rotational limits.

The instrument change position switches define the allowable range in which instrument change operations may occur.

CCW hard limit trip	379.2 degrees
CCW soft limit trip	369.2 degrees
CW hard limit trip	-200.4 degrees
CW soft limit trip	-190.5 degrees
Instrument Change Position	+/- 0.05 degrees

Untested Items

The azimuth, altitude, and rotator motor over-temperature interlocks were unable to be tested. The over-temperature interlock is a calculation internal to the PLC to determine the resistance of each motor based on the motor voltage and current values. A change in motor resistance below 2 ohms indicates an over heated motor. At the time of testing, there was no obvious way to generate I and V values from the amplifiers to generate an over-temp trip. After talking with Peter Prieto, the way to test the interlock is to drive a 2 ohm power resistor with the amplifier in local mode. This will be tested when the slip detection is installed. Although the resistance limit was not tested, the output from the PLC was tested to the interlock system.

Motor capstan slip detection and telescope velocity limits remain to be installed and tested. The hooks into the interlock system are complete and have been tested.

Known modifications

The altitude stow position switch may be modified as a result of the new building doors opening further. The current limit is based on the old building door height.

The December 15, 1999 teleconference suggested the possibility of the Altitude soft limits being applied to the Windbaffle only. This would allow the MCP to maintain the telescope servos in closed loop keeping an out of balance telescope in place. The present interlock prevents the Amplifiers from generating either a + or - signal to the motors while in a soft limit. An out of balance telescope can fall in the wrong direction making it difficult for the MCP to control the out of balance condition. The high level inhibits that would prevent motion in either direction would remain and be sent to the telescope amplifiers. As of this writing, this matter is still under consideration. Any change to the interlock system will be tested to verify proper operation.