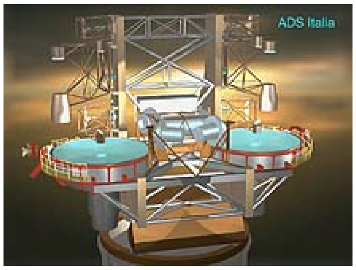

LBT PROJECT 2x8,4m TELESCOPE
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LBT PROJECT

2 X 8,4m OPTICAL TELESCOPE

LBT Dynamic Balancing System

System Requirements and Specifications

	Signature	Date
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Reviewed		
Approved		

1. Revision History

Issue	Date	Changes	Responsible
a	23-Feb-07	Initial Release	V. Gasho, J. Noenickx, J. Rill
b	01-Mar-07	Change wording in section 6.3 and value pressure value in 6.10.	V. Gasho

2. Table Of Contents

3. List Of Abbreviations

LBT	Large Binocular Telescope
TBC	To Be Confirmed
TBD	To Be Determined
I/O	Input/Output
TPLC	Telescope Programmable Logic Controller
PLC	Programmable Logic Controller
MCS	Mount Control System
LCP	Local Control Panel
ELRIO	Elevation Remote Input and Output

4. About this document

4.1. Purpose

The LBT Dynamic Balancing System uses a series of tanks mounted on the telescope, in which a 50/50 water-glycol mixture is pumped into the tanks as ballast to balance the telescope about the Y and Z axes. This system will be used to counterbalance the varying moments applied to the telescope when the Swing Arm systems are retracted and deployed. The purpose of this document is to define the overall Requirements and Specifications for the LBT Dynamic Balancing System.

4.2. Applicable Documents

[AD1] 580s001 Dynamic Balancing System - Functional Requirements

4.3. Reference Documents

[RD1] 561s003 Elevation Utilities – Electrical Supply Requirements
[RD2] 547s003 Swing Arm PLC Control Strategy
[RD3] 406x010 Horizontal Tank on Back Beam
[RD4] 406x011 Horizontal Tank on Front Beam
[RD5] 406x012 Upper Vertical Tank on Top Assembly
[RD6] 406x013 Lower Vertical Tank on C-Ring
[RD7] 406x014 Horizontal Tank for Back Beam
[RD8] 406x018 Horizontal Tank for Front Beam
[RD9] 406x015 Upper Vertical Tank
[RD10] 406x016 Lower Vertical Tank

5. System Description

The LBT telescope will be used in varying configurations depending on the type of observations being performed and which instruments are being utilized for those observations. To reduce the time required to achieve a different configuration, the telescope uses swing arms to introduce various optical components and/or instruments in and out of the light path. Typically changes in instrumentation, and/or optical components, required the addition of static weights. Traditionally steel or lead plates were used as ballast and were bolted or mechanically moved on the telescope to counterbalance the change in moment about the elevation axis. Here the LBT will also employ a fluidic dynamic balancing system to alleviate the operational overhead associated with static weights and make possible a more efficient and capable telescope.

The system uses 6 tanks on the elevation axis of the telescope (figure 1) that allow the transfer of fluid between the tanks in order to balance the telescope about the Y and Z axis. The primary use of the Y axis tanks is to balance the telescope when the swing arm configuration is changed. The Z axis is used to balance the telescope during instrument changes. Both axes will be used to fine tune the balance of the telescope.

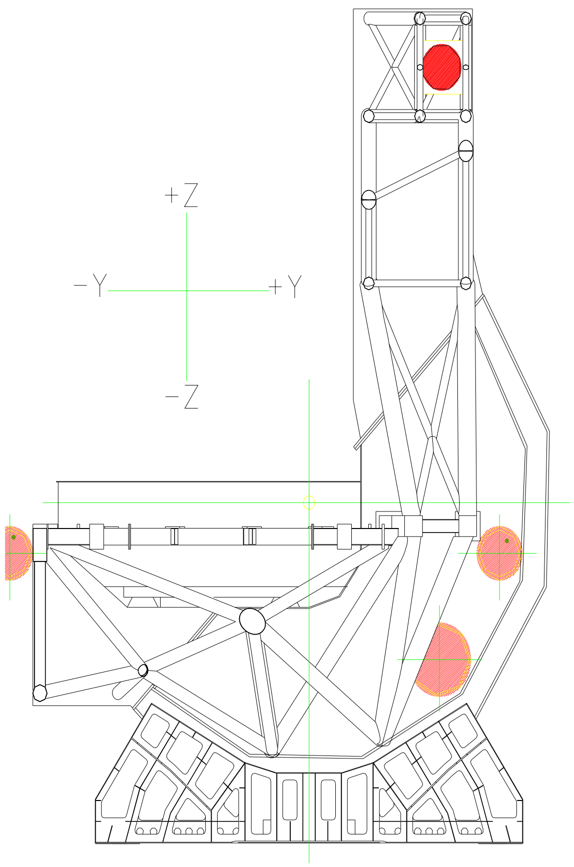

Figure 1. General Layout of dynamic balancing tanks.

6. Requirements

6.1. General Requirements

The system shall have separate independent sub-systems (pump, valves, and plumbing) for the Y and Z axes balancing.

The balancing system shall provide sufficient capacity to counterbalance up to 820 kN-m and 414 kN-m about the y-axis and z-axis respectively.

The pumps for each axis shall deliver a flow rate of at least 200 liters per minute in all conditions.

The system shall provide a fluid mass metering accuracy of 0.5% (TBC) or +/- 2.5 kg (TBC) (with a goal of 0.1% (TBC) or +/-0.5 kg (TBC)) of transferred mass whichever is larger.

The system shall operate at zenith elevation angle only and with stow pins installed.

The system shall be designed for a 25 year lifetime.

6.2. Thermal

The temperature of any exposed external surfaces of the system shall not be more than +/- 1 C of ambient temperature after a period of 30 minutes has elapsed since the last pumping operation was completed.

6.3. Mechanical

All components of the system shall be securely mounted and all components weighing more than 5 kg shall have a structural resonant frequency above 10 Hz.

The tanks shall be sufficiently baffled to prevent the fluid from sloshing and degrading the tracking performance of the telescope. Therefore the measured sloshing disturbance five seconds after a slewing motion shall be no more than 100 Nm at a frequency at or below 1.5 Hz. In addition said disturbance shall roll off in amplitude at the rate of 20 dB per decade of frequency above 1.5 Hz.

The system shall be designed to prevent dry running of the pumps as well as overfilling or over pressurization of the tanks.

The fluid shall be a 50/50 ethylene glycol-water mixture with an appropriate amount of anti-foaming additives as needed.

Any vents to the ambient environment shall be screened to prevent insects or other debris from entering the system. The vents shall be designed in such a way to prevent fluid from exiting into the telescope chamber with either a float safety valve or other suitable system. The vent mechanism shall provide venting for the tank in all telescope orientations.

The pump shall have a pressure relief bypass system to prevent damage to the system.

The system shall be easily filled and emptied for maintenance purposes.

The system shall use stainless steel tubing for the plumbing system or other suitable material with corrosion protection.

The plumbing system shall be designed in such a way to minimize the number of connections to reduce the possibility of leaks.

The piping on either side of each pump, in each subsystem, shall have an analog pressure gage for maintenance and troubleshooting purposes.

6.4. Electrical

The system shall operate on 480 3-Phase [RD1] power supply at 60Hz and consume no more than 7.2 kW (TBD) from the main power supply.

The system shall use off-the-shelf electronics as much as is practical to do so. The system shall use the existing Allen Bradley series 1756 ControLogix PLC to implement the control logic to be compatible with the other existing sub-system.

Hardware interlocks shall be used for the purposes of lockout, e-stops, and stow pin insertion. The act of locking out the system, activating an e-stop, or removing the stow pin, shall have the effect of disabling the power to the pumps and valves.

6.5. Controls

The Balancing control system will incorporate more Allen-Bradley's Remote I/O modules to the telescope control system. It shall perform the following tasks:

- Drive the two pumps for the Y and Z axis (if the I/O modules are not capable of driving the pumps directly, TBD driver will be used to drive the pumps, and the I/O modules are to control the TBD drivers)
- Read pump motor currents (TBD)
- Drive the valves to control the flow between the two sets of tanks
- Interface to the liquid level sensors on the tanks to obtain the fluid levels (likely analog inputs)
- Interface to the flow meters to monitor fluid flow between the tanks (likely analog inputs) (TBD).
- Interface to the pressure transducers in the two sets of circuits to obtain pressure information (likely analog inputs) (TBD)
- The Dynamic Balancing ELRIO module will communicate with the TPLC over existing fiber optic cable using ControlNet protocol. This is to 1) provide the status information and send requests to the commanding unit; 2) Receive commands to operate the pumps and valves.

- The communication between the Mount Control System (MCS) and TPLC is an established link over the Ethernet in the existing system. The Balancing sub-system shall be remotely controlled from the LCP or MCS via the TPLC.

The system shall balance the telescope based on the configuration of the telescope that is selected from the MCS.

The system shall also be manually operable from the Local Control Panel (LCP) for maintenance and for fine adjustment of the telescope balance.

The ability to calibrate the system shall be accomplished through either the MCS or LCP. The units that the system is calibrated in shall be kg-m.

6.6. Interfaces

The dynamic balancing system shall interface to the ELRIO in the upper right tree house.

The system shall interface to the TPLC to determine the configuration of the telescope and then command the system to transfer the correct amount of fluid to the correct tank.

The system shall report each individual tank fluid level to the TPLC when the telescope is stowed at zenith.

6.7. Interlocks

6.7.1. Software Interlocks

- A pump shall stop if a tank fluid level is over its upper threshold and the flow direction is toward that tank to prevent overflow.
- A pump shall be halted if the flow meter senses no flow after the pump is turned on for 1 (TBD) second.
- High pressure or low pressure indication from pressure transducer.

6.7.2. Hardware Interlocks

Hardware interlocks shall be provided for the following conditions and shall have the effect of disabling the power to the pumps and valves:

- Any telescope E-stop activated.
- Stow-pin retracted.
- Lockout switch in off position.

6.8. Software Interfaces

- Communication between the TPLC and Dynamic Balancing portion of the ELRIO module shall be transmitted over existing fiber optic cable using ControlNet protocol.

- Control and status information between the ELRIO and TPLC shall take place over ControlNet using "tags" as defined in [RD2].

- PLC Software

  The PLC software designed to run on the TPLC shall be able to perform the following functions:

  1) Read/write all defined Balancing system digital inputs/outputs on the ELRIO
  2) Read/write all defined Balancing system analog inputs/outputs on the ELRIO
  3) Provide local operation of the Balancing system using the Local Control Panel installed at the TPLC
  4) Implement all software interlock logic to prevent any fault operation
  5) Balance the telescope based on the configuration of the telescope that is selected from the MCS or LCP.

Note that a mapping of telescope configuration to fluid levels is pre-calculated, stored and logged in the PLC. Therefore, for a telescope configuration, the MCS or LCP would issue a command to the Balancing system to balance the telescope based on that configuration. The system will also accept commands from the MCS or LCP to allow for fine tuning of the balance. The Balancing system carries out the detail operations for the pumps and valves while monitoring the software interlock and fault conditions during the operation.

6.9. Wiring and Electro-Magnetic Interference

- Input power shall be conditioned with high-quality industrial filters and include over-voltage and over-current protection.

- All control and power signals shall be properly sized and rated for current carrying capacity, voltage break-down, operating temperature, etc.

- All voltage and current protection devices shall be properly sized for the circuit that they are providing protection.

- Control signals shall be separated from power signals whenever possible.

- All control and power signals shall be properly protected (i.e. shielded, grounded, etc) to minimize susceptance to electro-magnetic interference (conducted/radiated) and from generating harmful electro-magnetic interference (conducted/radiated) to other systems on the telescope.

- All signals leaving the telescope elevation or azimuth frame shall do so via fiber optic cable whenever possible.

6.10. Environmental Conditions

Components of the system shall experience the following conditions for operation and for storage:

- Storage temperature: -30 to +50°C
- Operating temperature: -20 to +25°C
- Storage pressure: 500 to 760 Torr
- Operating pressure: 500 to 750 Torr
- Storage humidity: 5 to 80%
- Operating humidity: 5 to 95%
- Maximum operating windspeed: 80 km/h
- Suvival windspeed: 120 km/h
- Altitude: 0 m - 3200 m

7. System Specifications

7.1. Component Specifications

The following is the individual component specifications for the dynamic balancing system.

7.1.1. Pumps

There shall be one pump for each axis balancing system (y-axis and z-axis) and each pump shall meet the following specifications.

- Power: 480 3-Phase AC

- Controlled by soft start drive unit.
- Pump Capacity: 200 liters/min minimum (fluid viscosity ≤ 20 cSt @ -20C)
- Sustain specified minimum flow rate at pressures below 4 bars (TBD).
- Positive displacement style pump.
- Reversible operation.
- Bypass relief valve set at 4 bars (TBD).
- Low maintenance.
- Design lifetime of 25 years.
- Compatible with environmental conditions in section 6.10.

7.1.2. Fluid

The fluid shall consist of a 50/50 by volume ethylene glycol/ water mixture. And shall have rust and bacterial inhibitor additives as well as antifoaming agents introduced as needed.

Additional specifications are as follows:

- The fluid shall be free from debris larger than 100 micron.
- Compatible with environmental conditions in section 6.10.

7.1.3. Valves

7.1.3.1. Automatic Valves

The automatic valves used in the system shall be either fully opened or fully closed with the position able to be remotely monitored and controlled. They also shall have a manual override in case of failure and for maintenance.

Additional specifications are as follows:

- Power: 480 3-Phase AC
- Compatible with environmental conditions in section 6.10.

7.1.3.2. Manual Valves

Manual valves used in the system shall be of a ball type and shall be either fully open or closed during operation.

Compatible with environmental conditions in section 6.10.

7.1.4. Piping

Stainless steel piping or other corrosion resistant material shall be used for all plumbing. An effort shall be made to minimize the number of connections. All piping shall be firmly secured to the telescope structure to prevent unwanted vibrations with corrosion resistant clamps.

Piping shall be cleaned before installation.

If required, insulation on the pipes will be such that it can be removed for piping inspection as well as clad with a suitable material to prevent deterioration.

Additional specifications are as follows:

- Minimum Burst Pressure: ≥ 20 bar
- Compatible with environmental conditions in section 6.10.

7.1.5. Tanks

The tanks have been already produced and installed on the telescope. Details of the tank construction and installation can be found in [RD3], [RD4], [RD5], [RD6], [RD7], [RD8], [RD9] and [RD10]. Below are the pertinent specifications for the tanks.

- Material: 306 Stainless steel
- Baffled to prevent tank sloshing as required in section 6.3
- Capacities
    - 2 x 6000 liter tanks for y-axis balancing
    - 4 x 1500 liter tanks for z-axis balancing
- Ports for fluid level sensor.
- Filler, vent, inlet and outlet ports.
- Compatible with environmental conditions in section 6.10.

If required, insulation on the tanks will be such that it can be removed for tank inspection as well as clad with a suitable sheet metal to prevent deterioration.

7.1.6. Analog Pressure Gages

The analog pressure gages shall meet the following specifications:

- Range: 0 - 10 bar (gage pressure)
- Accuracy: +/-0.08 bar
- Compatible with environmental conditions in section 6.10.

7.1.7. Inline Strainers

The inline strainers shall meet the following specifications:

- Max Pressure: 10 bar (gage pressure)
- Filter Size: ≤ 100 microns
- Compatible with ethylene glycol/water mixture
- Replaceable filter
- Compatible with environmental conditions in section 6.10.

7.1.8. Electrical and Controls

7.1.8.1. Fluid Level Sensors

The fluid level sensors shall meet the following specifications:

- Power: 15-30 VDC (TBD)
- Accuracy: +/- 5 mm (TBD)
- Compatible with environmental conditions in section 6.10.

7.1.8.2. Pump Control

The pump control shall meet the following specifications:

- Input Voltage 480 VAC 3 phase
- Output Power 5.5 kW
- Efficiency TBD
- Soft start capability.
- Compatible with environmental conditions in section 6.10.

7.1.9. Mass Flow Meters

The flow meters shall meet the following specifications:

- Power: 15-30 VDC
- Mass Flow Accuracy: 0.5% FS (0.1% FS goal)
- Maximum mass flow rate: 300 kg/min
- Reynolds Number Range: TBD
- Capability of measuring reverse flow and capability to read flow direction
- Compatible with fluid viscosity of 3-20 cSt
- Compatible with ethylene glycol/water mixture

- Max operating pressure: 10 bar
- Compatible with environmental conditions in section 6.10.

7.1.10. Pressure Transducers

The pressure transducers shall meet the following specifications:

- Power: 15-30 VDC
- Range: 0 - 10 bar (absolute pressure)
- Accuracy: +/-0.04 bar
- Compatible with environmental conditions in section 6.10.

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