Observatory Automation Project Detailed Design Review Electric Dome Drive System (EDDS)

Steven Bauman

Contributors: Sarah Gajadhar, Grant Matsushige, Ivan Look, Derrick Salmon, Ralph Taroma, Larry Roberts, Casey Elizares, Tyson Arruda, William Cruise, Tom Vermeulen, Jim Thomas, DeeDee Warren, Karun Thanjavur

Version 1.1 July 9, 2010

MEMORANDUM

To : D. Salmon, R. Atapattu, K. Ho, G. Matsushige, L. Roberts, R. Taroma

From : W. Cruise

Date : 23 January 2008

Subject : Another possibility for dome rotation upgrade

We have recently had presentations and proposals from Rexroth, the Canadian company which supplied the original dome drive system. One of the proposals was a full electrical approach to performing dome rotation. The cost of that proposal, approximately $152,000, makes it undesirable for our application. I also feel that their proposal has several items we do not need ($45,000 of PC's, for example), and seems overly complex and redundant for our application.

However, there may be another, simpler, and less expensive way to perform the change from hydraulic control to electrical. In talking with Larry and Grant, I believe we have come up with a tenable way to go electric within our budget. Of course, at this point there has been no real engineering done on this, and the plan is just a basic concept. This memo is being written to see if there is any interest in tackling the job in-house.

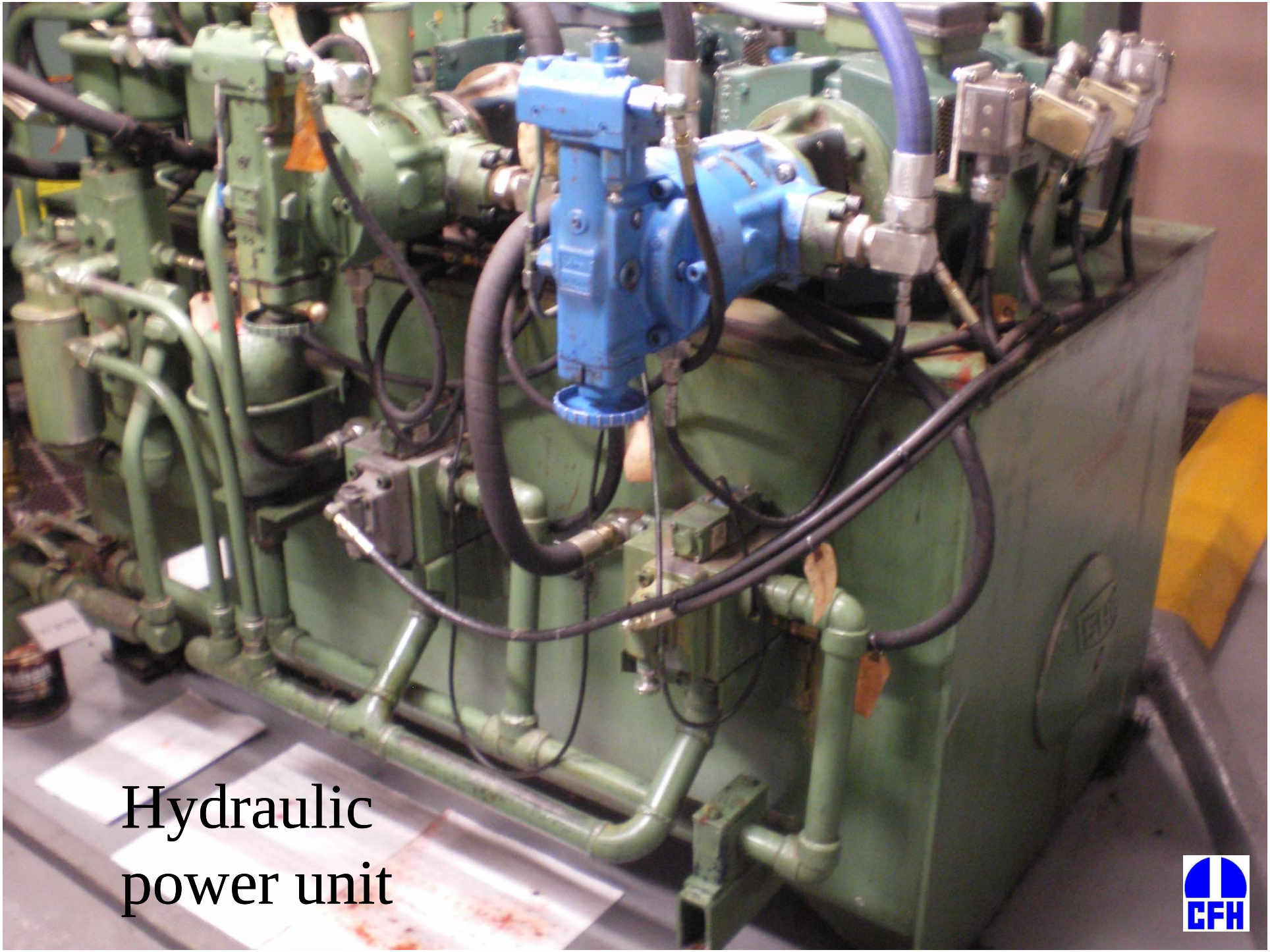
The plan, to put it very simply, is to replace the three hydraulic drive motors with three Variable Frequency Drive AC motors. The motors would be 20 HP, the same as proposed. They would require adapter plates, which are also in the proposal. They would be driven either by one VFD control unit, or one VFD unit per motor. The variable frequency drives would be controlled by the present dome rotation PLC which presently controls the hydraulic servo valve. It would provide motor velocity commands and would servo control the dome in the same method it presently does with the hydraulic system. We would also have to tackle the job of holding the drive wheels down on the track, as in their proposed system.

In this plan our main outlay would be the VFD motors, adaptor plates, VFD drive electronics, electrical wiring to connect it all up, and changes to the PLC software to control it. We should be able to quickly achieve performance equal to the present dome control system. In a quick estimate, I would guess that we could bring this in for under $50,000 and a good bit of manpower. One must also consider that we would have to contribute considerable manpower for either the Rexroth hydraulic or electrical proposal. I think we could develop a good plan for switching systems with minimal down time.

This memo is intended to be an introduction to the possibility for this option. If there is interest, the next step would be to further investigate the possibilities for getting motors and drives with the capabilities needed. We might need to go for outside consulting help in selecting the proper components. At that time we should be able to present a reasonable design, with realistic cost and manpower figures.

Scope

- Design solution to replace the hydraulic power unit and operate the dome drive system with electronically controlled motor units.
- Remotely control the system under the guidelines provided by the OAP project
- Meets the specifications and requirements formed for the dome drive electrical upgrade.
- Detailed design changes to the existing system, mechanical interfaces, safety considerations, anticipated costs and estimated manpower resources.


Hydraulic
power unit

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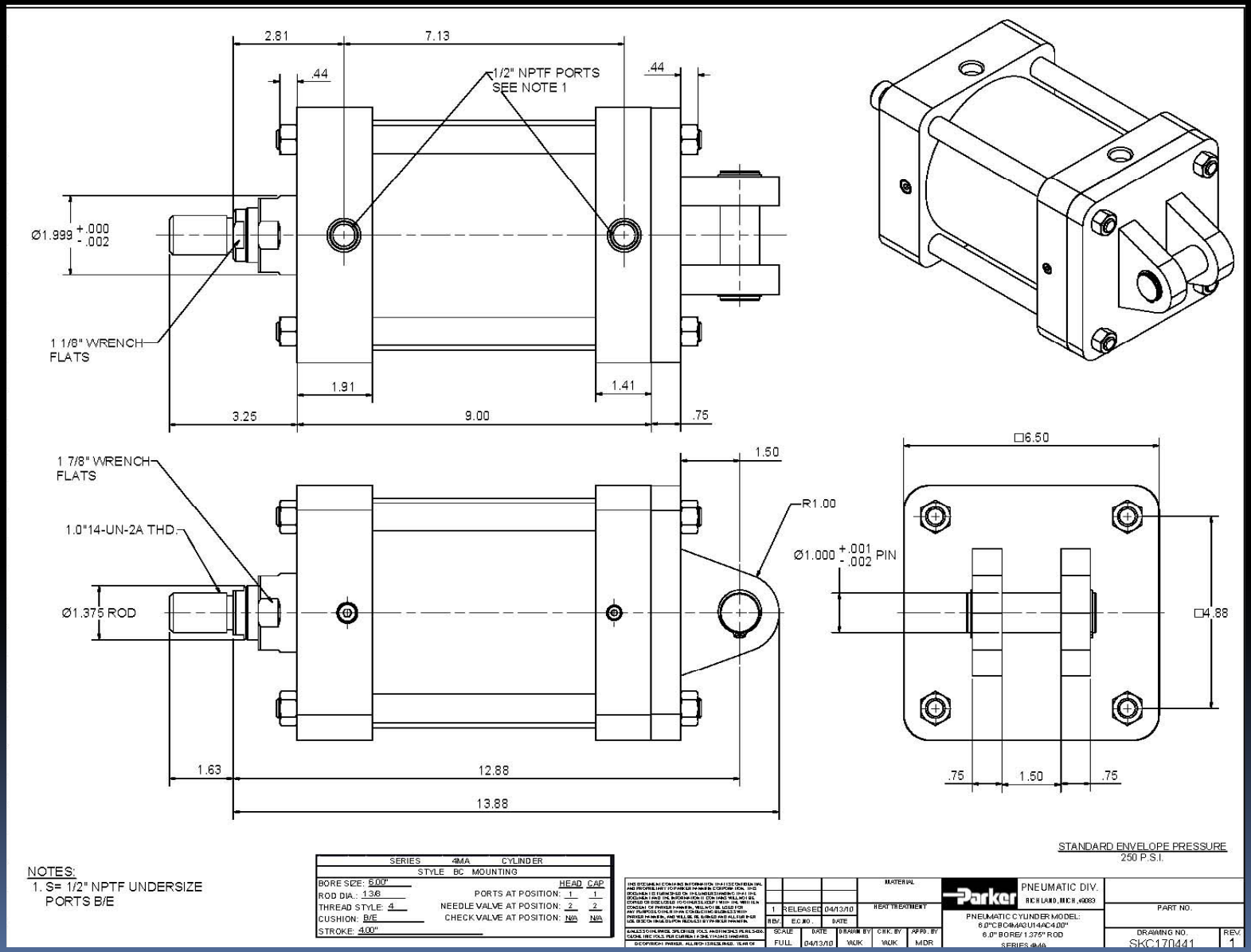
Requirements

Dome Drive Requirements needed for OAP

- **Remotely controlled dome drive operation**
  - The dome drive must be capable of being operated remotely in a "safe" reliable manner from Waimea.
  - NO possible remote control from Waimea when in manual mode at the summit.
- **Remote monitoring and status information**
  - The electronic drive system shall provide necessary status and system information.
  - Phase 2 will provide a status page for motor controller system status and monitoring.
- **Manual Control**
  - The drive system control panel must allow local control of the drive system with the same or improved safety features.
- **Preventative Maintenance**
  - The dome drive system shall provide access to all serviceable components and minimize the need for scheduled maintenance.
- **Improved Reliability**
  - The new electronic dome drive system should increase the reliability and minimize repairs.
- **Safe Interlocking**
  - The dome drive system shall provide safety interlocking to prevent unauthorized remote control of the drive system. It shall protect personal and other critical systems when/if other systems shutdown or malfunction
  - Lock out of the system for maintenance.

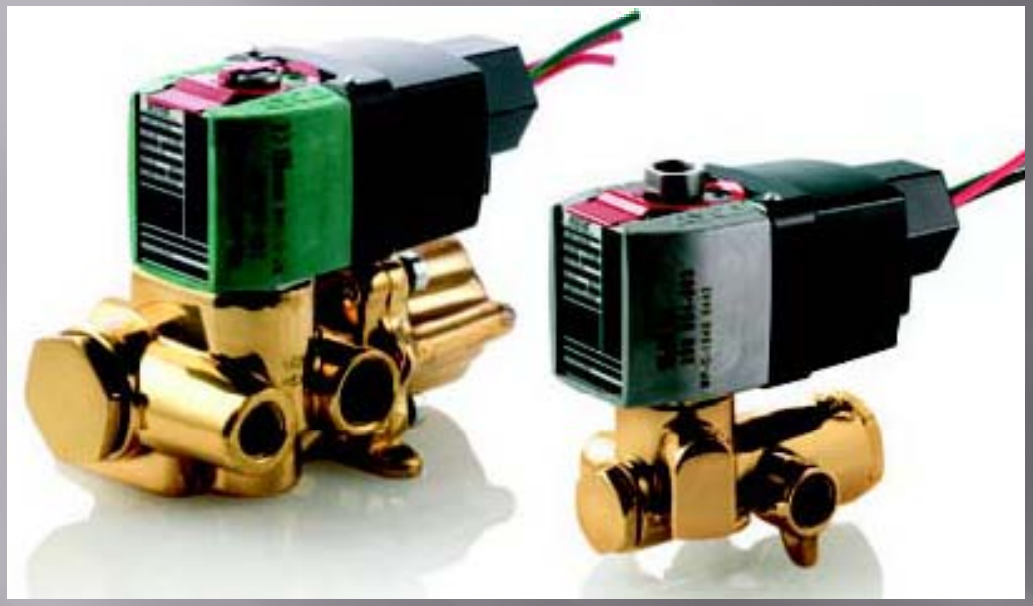
- Modify 5th floor spacer room to allow for more space around the motor.
- Alterations will improve maintenance and repairs in the future.

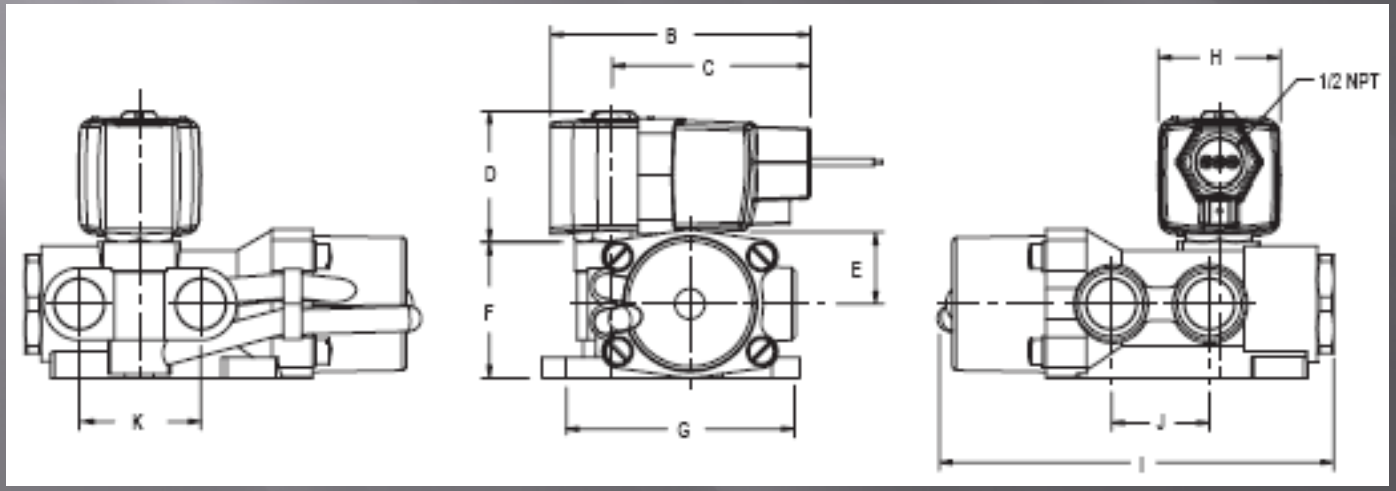
Replacement Actuator



Parker Hannifin Pneumatic actuator 122psi operating pressure

Solenoid valve

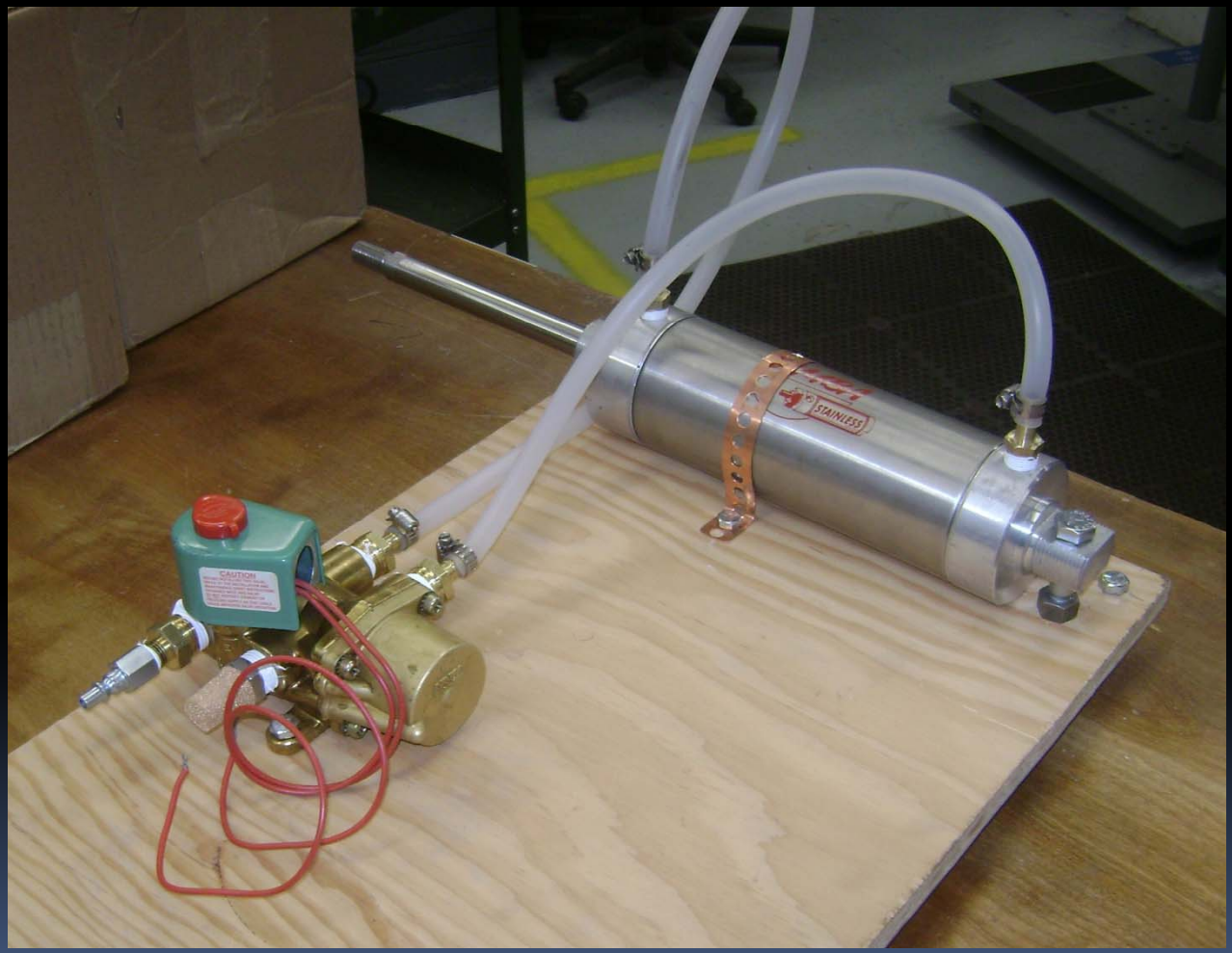




- 4-way valve
- 1 pressure port, 2 cylinder ports, 1 exhaust port
- Built in surge suppression
- 80% reduction in power use
- Only draws 2 watts of power
- 100-240/AC or DC
- Rain tight, dust tight, and Ice resistant.

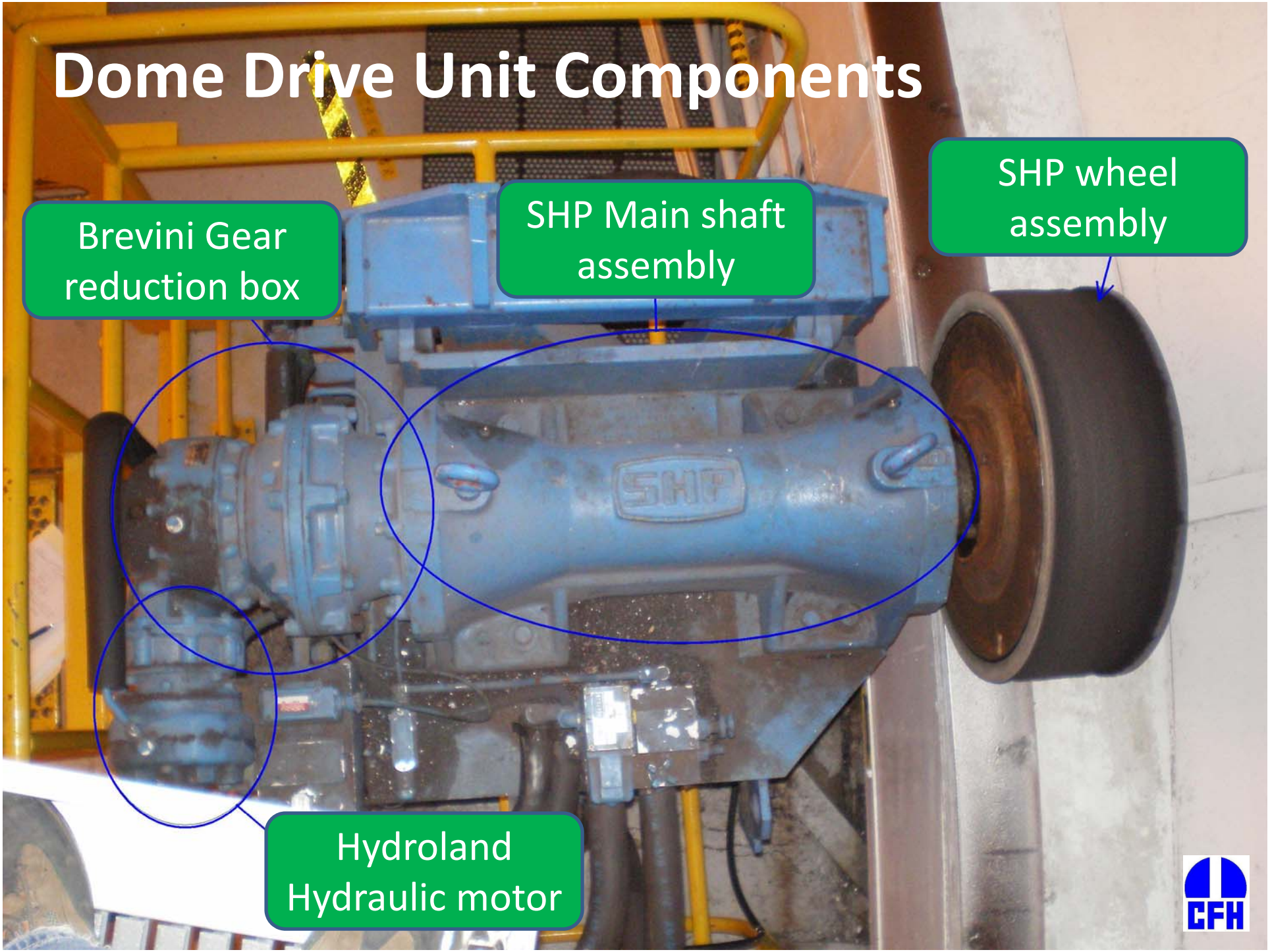
Proof of concept

The Daycrew assembled and bench tested a similar two port actuator and solenoid valve with 122psi operating pressure to verify and validate the design idea.



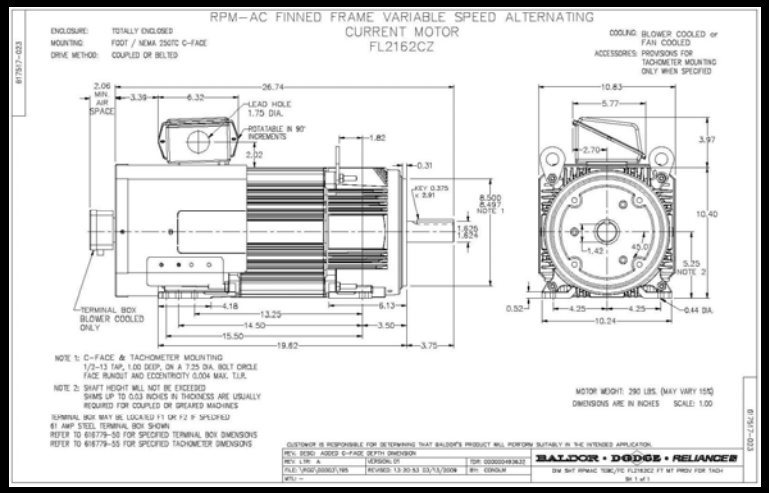

SHP
ENTERPRISES

Dome Drive Unit Components

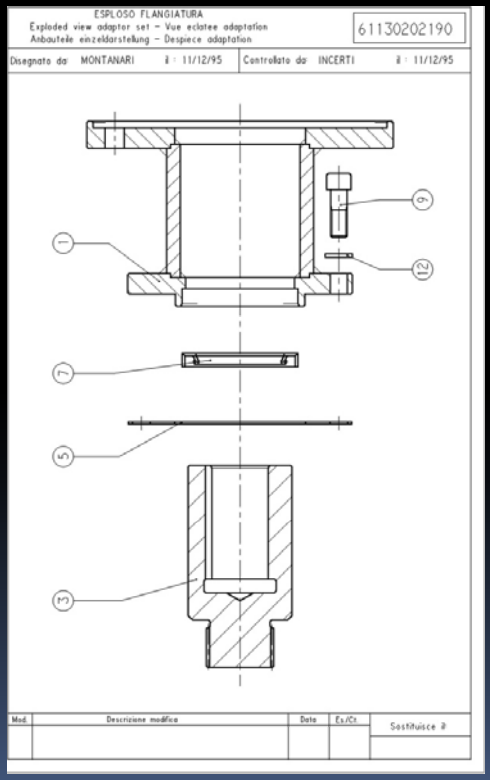


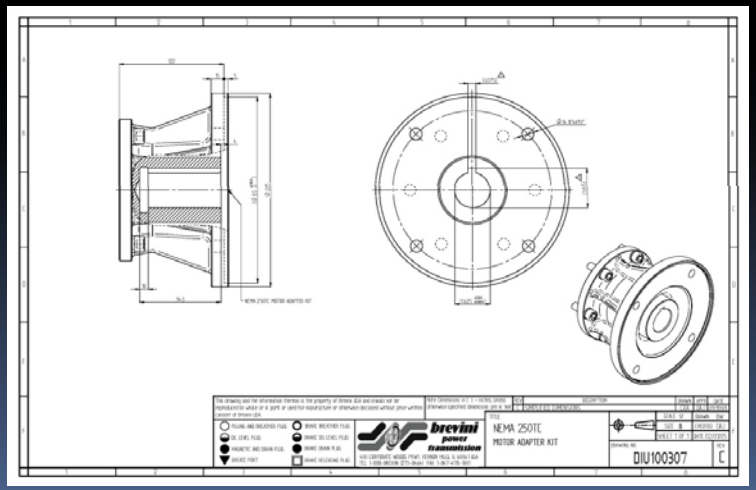
New Motors and Adapter

Baldor RPM AC 20HP motor 1750RPM 3PH 60HZ



Exploded adapter kit view





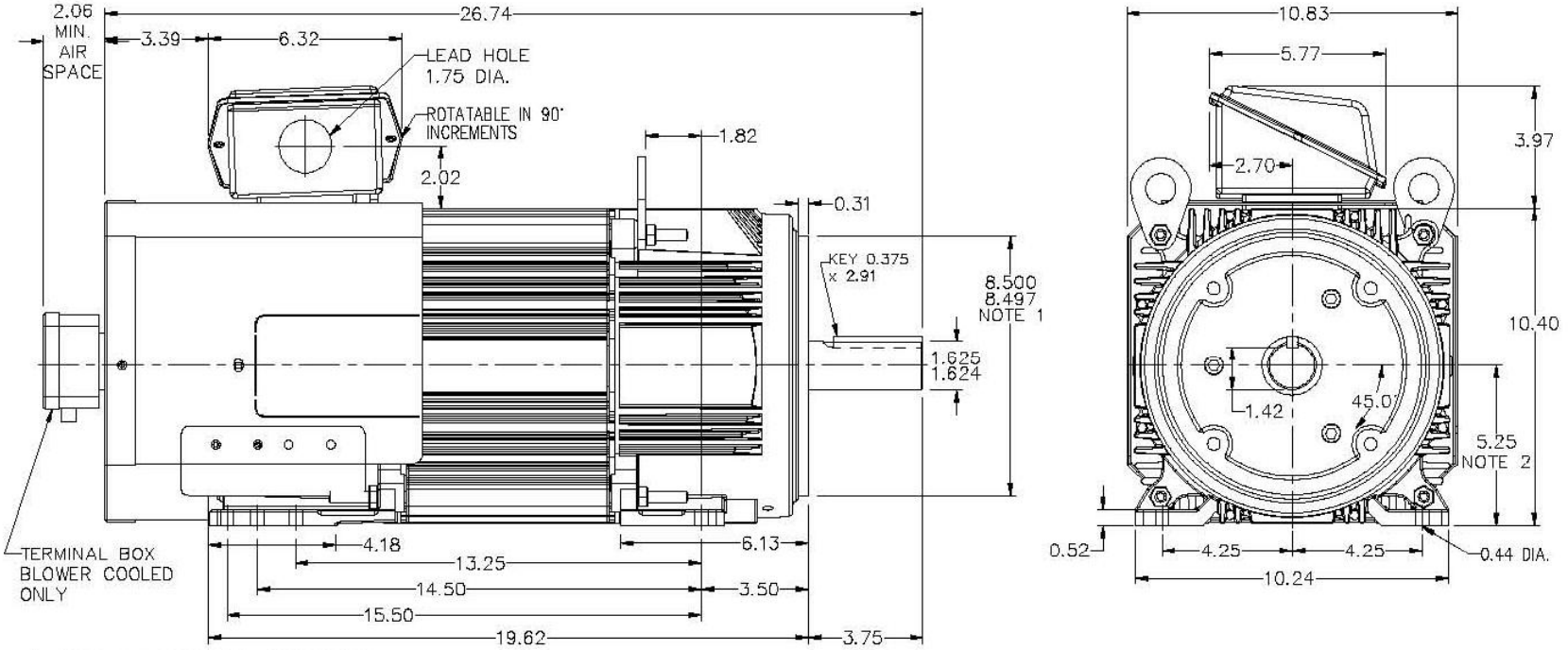
Brevini Nema 250TC Motor adapter flange

617517-023

RPM–AC FINNED FRAME VARIABLE SPEED ALTERNATING CURRENT MOTOR FL2162CZ

ENCLOSURE: TOTALLY ENCLOSED
MOUNTING: FOOT / NEMA 250TC C-FACE
DRIVE METHOD: COUPLED OR BELTED

COOLING: BLOWER COOLED or FAN COOLED
ACCESSORIES: PROVISIONS FOR TACHOMETER MOUNTING ONLY WHEN SPECIFIED



NOTE 1: C–FACE & TACHOMETER MOUNTING
1/2–13 TAP, 1.00 DEEP, ON A 7.25 DIA. BOLT CIRCLE
FACE RUNOUT AND ECCENTRICITY 0.004 MAX. T.I.R.

NOTE 2: SHAFT HEIGHT WILL NOT BE EXCEEDED
SHIMS UP TO 0.03 INCHES IN THICKNESS ARE USUALLY REQUIRED FOR COUPLED OR GREARED MACHINES

TERMINAL BOX MAY BE LOCATED F1 OR F2 IF SPECIFIED
61 AMP STEEL TERMINAL BOX SHOWN
REFER TO 616779–50 FOR SPECIFIED TERMINAL BOX DIMENSIONS
REFER TO 616779–55 FOR SPECIFIED TACHOMETER DIMENSIONS

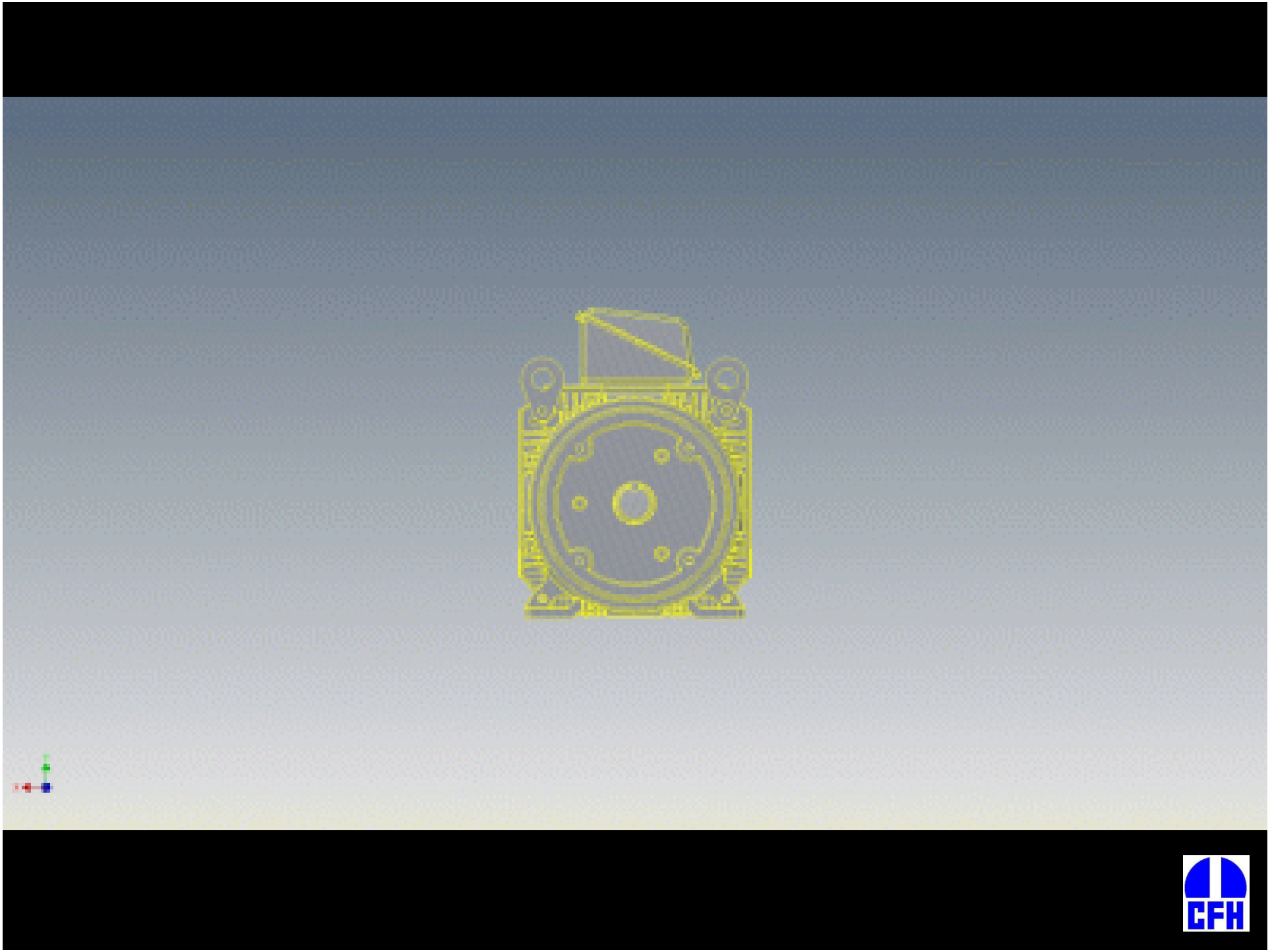
MOTOR WEIGHT: 290 LBS. (MAY VARY 15%)
DIMENSIONS ARE IN INCHES SCALE: 1.00

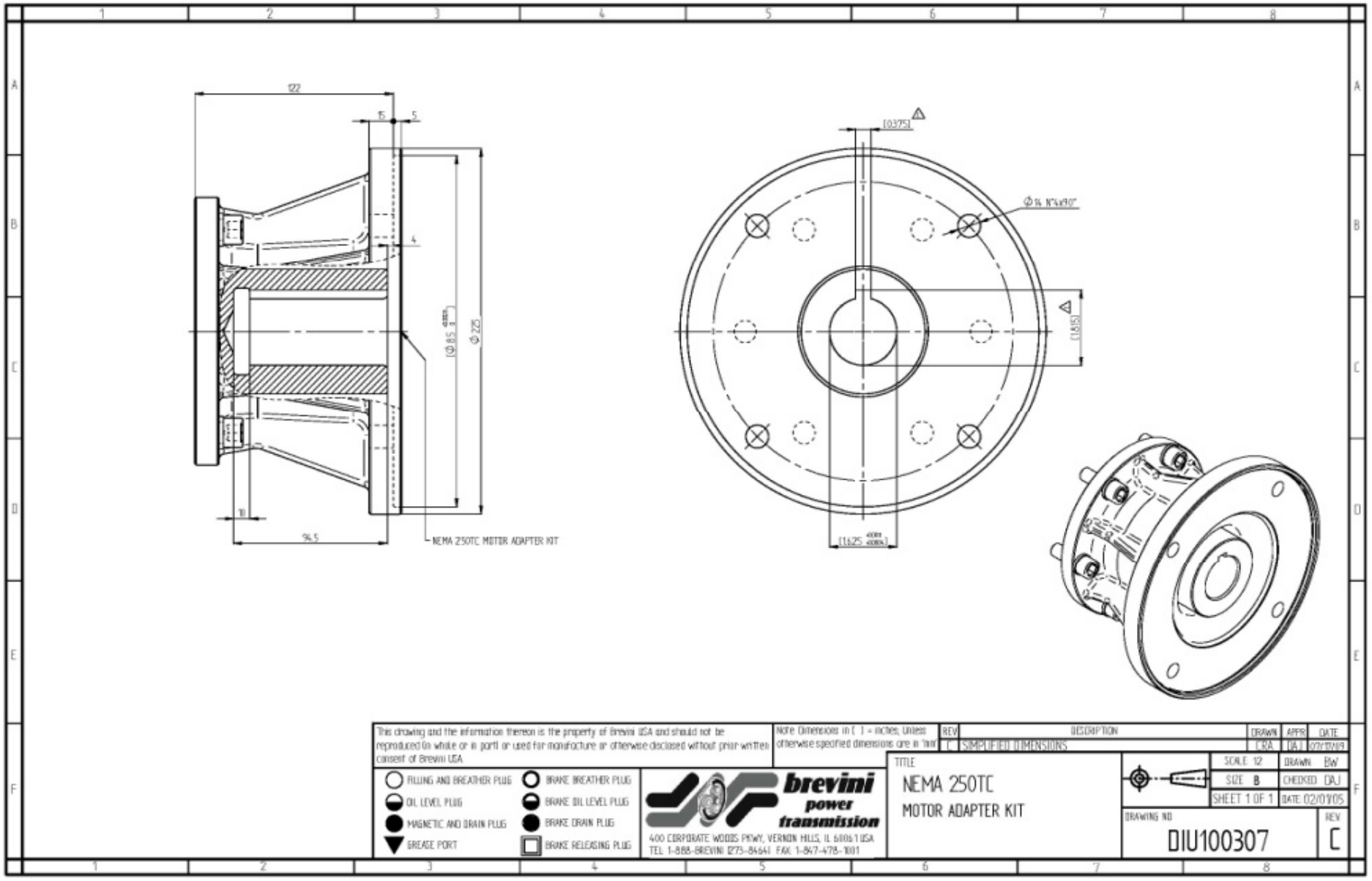
REV. DESC: ADDED C–FACE DEPTH DIMENSION		
REV. LTR: A	VERSION: 01	TDR: 000000493632
FILE: \RGG\00003\195	REVISED: 13:20:53 03/13/2009	BY: CONDLM
MTL: –		

BALDOR • DODGE • RELIANCE

DIM SHT RPMAC TEBC/FC FL2162CZ FT MT PROV FOR TACH
SH 1 of 1

617517-023




122
15
5
4
Ø 85.5
Ø 225
11
96.5
NEMA 250TC MOTOR ADAPTER KIT
[.0375]
Ø 14. N°4x90°
[1.625]
This drawing and the information thereon is the property of Brevini USA and should not be reproduced (in whole or in part) or used for manufacture or otherwise disclosed without prior written consent of Brevini USA
Note: Dimensions in [ ] = inches; Unless otherwise specified dimensions are in mm
REV
DESCRIPTION
DRAWN
APPR
DATE
C
SIMPLIFIED DIMENSIONS
CRA
DAJ
02/01/05
FILLING AND BREATHER PLUG
OIL LEVEL PLUG
MAGNETIC AND DRAIN PLUG
GREASE PORT
BRAKE BREATHER PLUG
BRAKE OIL LEVEL PLUG
BRAKE DRAIN PLUG
BRAKE RELEASING PLUG
brevini power transmission
400 CORPORATE WOODS PKWY, VERNON HILLS, IL 60061 USA
TEL 1-888-BREVINI (273-8464) FAX 1-847-478-1001
TITLE
NEMA 250TC
MOTOR ADAPTER KIT
SCALE 1:2
SIZE B
SHEET 1 OF 1
DRAWN BW
CHECKED DAJ
DATE 02/01/05
DRAWING NO
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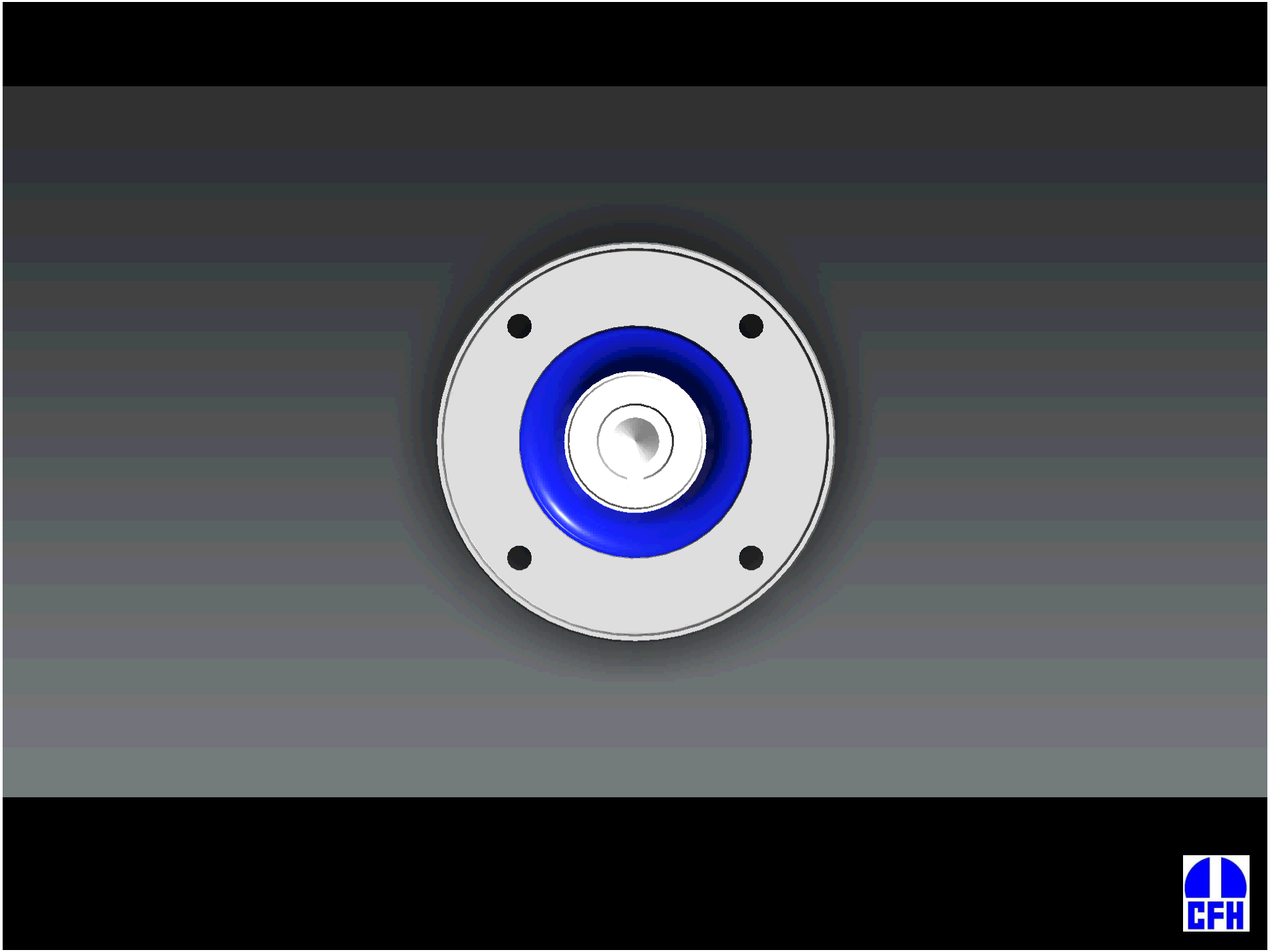

Motor Integration

Drive unit modifications

1) Valve off the supply and return hydraulic lines
2) Drain and remove the lines from the hydraulic motor and cap them.
3) Remove hardware and the hydraulic motor
4) Remove hardware and the motor adapter assy.
5) Unbolt the Gearbox from the SHP main shaft assy.
6) Drain the gearbox
7) Rotate the gearbox 90˚ with the input shaft up.
8) Rebolt the gearbox
9) Replace the gearbox oil
10) Install electric motor to the new adapter kit
11) Install the hardware and motor/adapter on the gearbox


AOB
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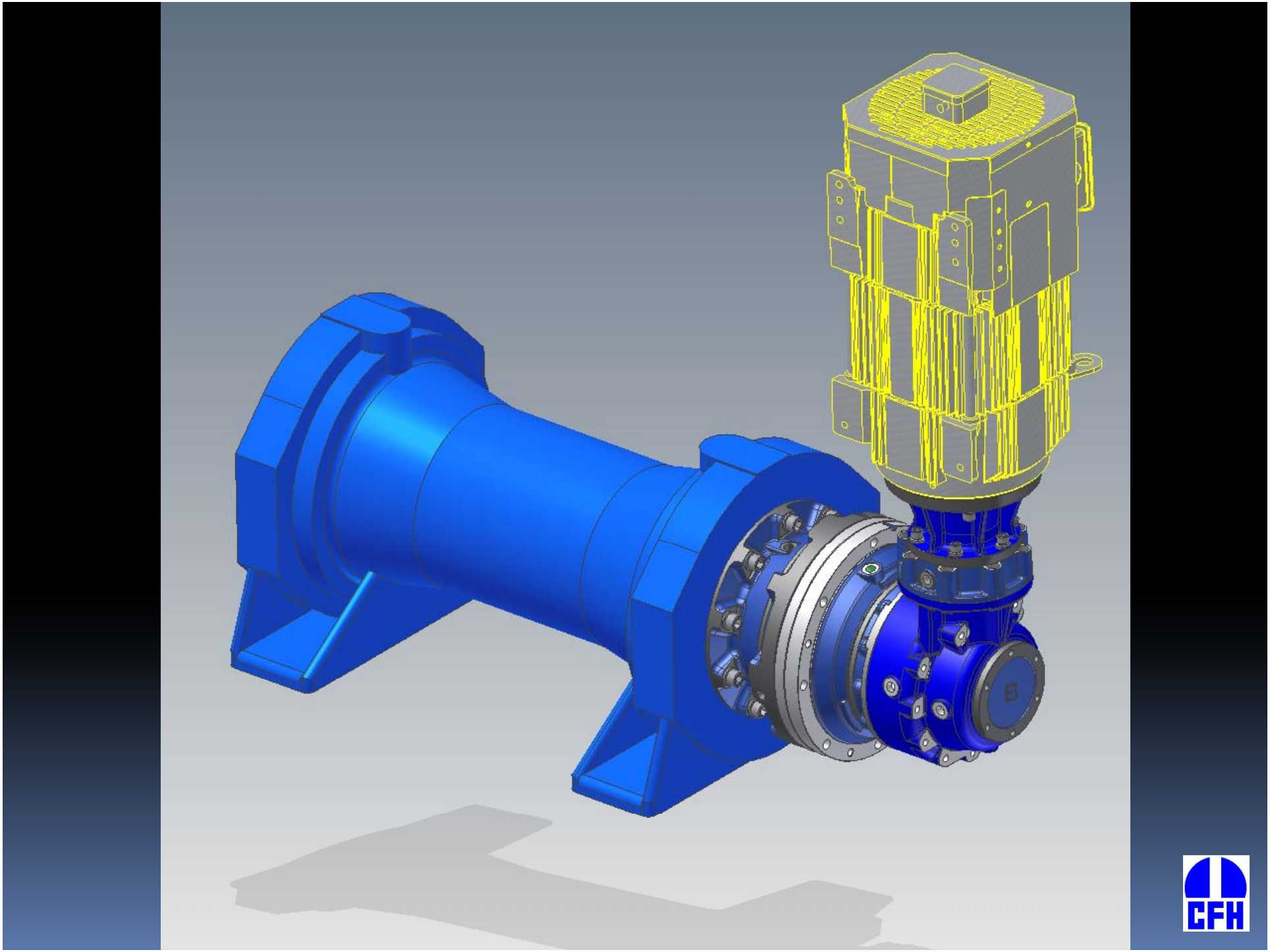
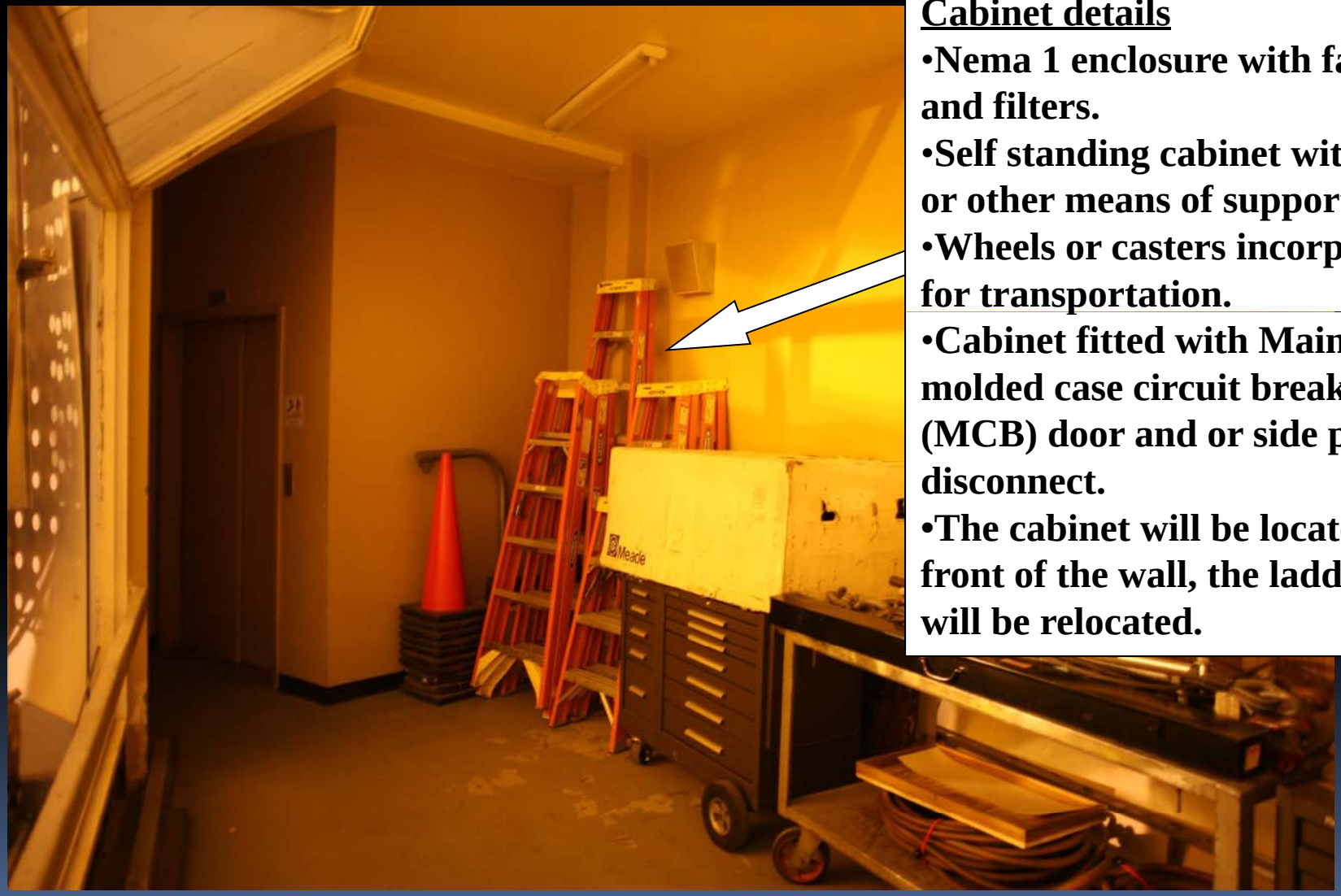


Location of Dome Drive cabinet



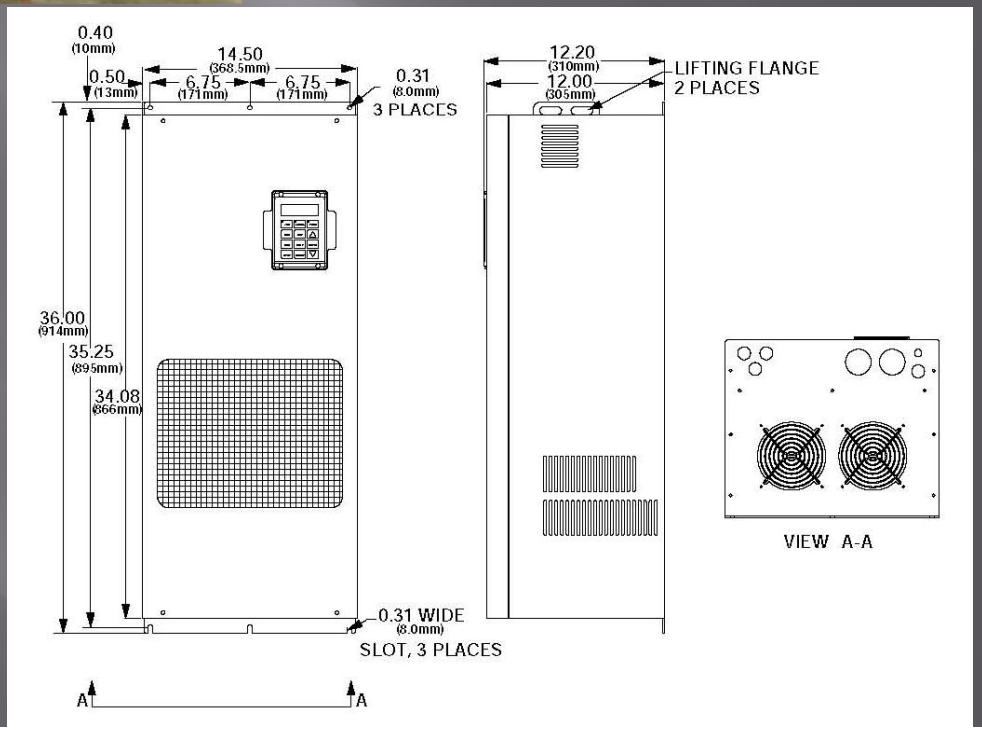
Cabinet details

- **Nema 1 enclosure with fans and filters.**
- **Self standing cabinet with legs or other means of support.**
- **Wheels or casters incorporated for transportation.**
- **Cabinet fitted with Main molded case circuit breaker (MCB) door and or side panel disconnect.**
- **The cabinet will be located in front of the wall, the ladders will be relocated.**

Dome Drive Motor Controller Cabinet

- Power distribution terminal block for three (3) branch circuit each with:
- 50 Amp molded case circuit breaker (MCB) for inverse fault protection (loss of line or line short circuit line when drive is regenerating) .
- Thermostatically controlled drive input contactor to prevent power up at below -10 deg C .
- 3% Input line reactors
- ZD22H420-EL drive
- Output motor load reactors

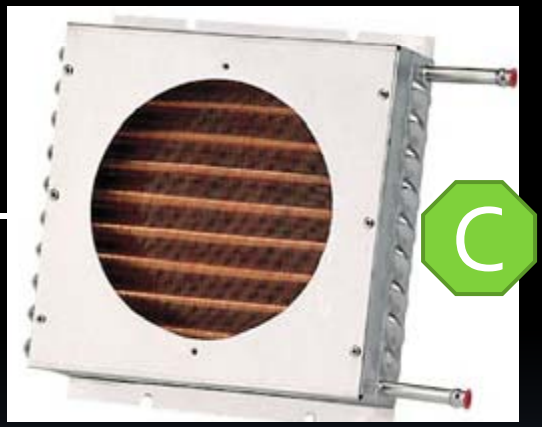
*Grant will discuss the controls of the system



Heat Mitigation strategy

- Heat dissipation estimates
  - Motors At Full Speed (3.4HP @ 60˚/min) ~ 95 Watts
    - **Meets requirement criteria, no requirement for mitigation**
  - Motor Controllers At Full Speed (3.4HP @ 60˚/min) ~ 256 Watts
    - Worst case estimate, difficult to estimate due to intermittent operation

B



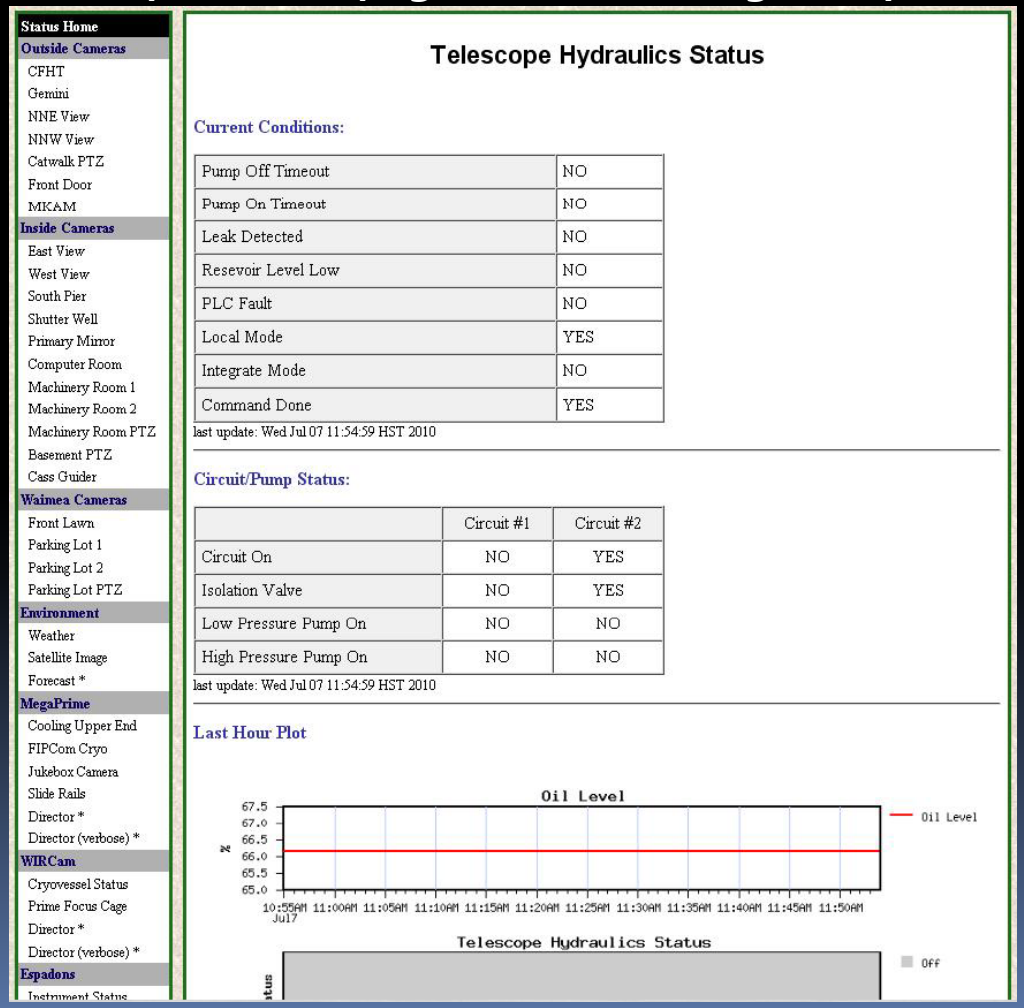
C

PLAN

- A) Vent the motor controller heat into the visitor's gallery. Sealed room with no other heat sources.
- B) Add a standard ventilation fan above the visitors staircase door to vent the room air volume into the staircase
- C) Add a small Thermatron or Lytron heat exchanger using the building glycol system to the bottom of the Baldor cabinet.

Monitoring and Status Information Phase 2

Example status page for monitoring the system



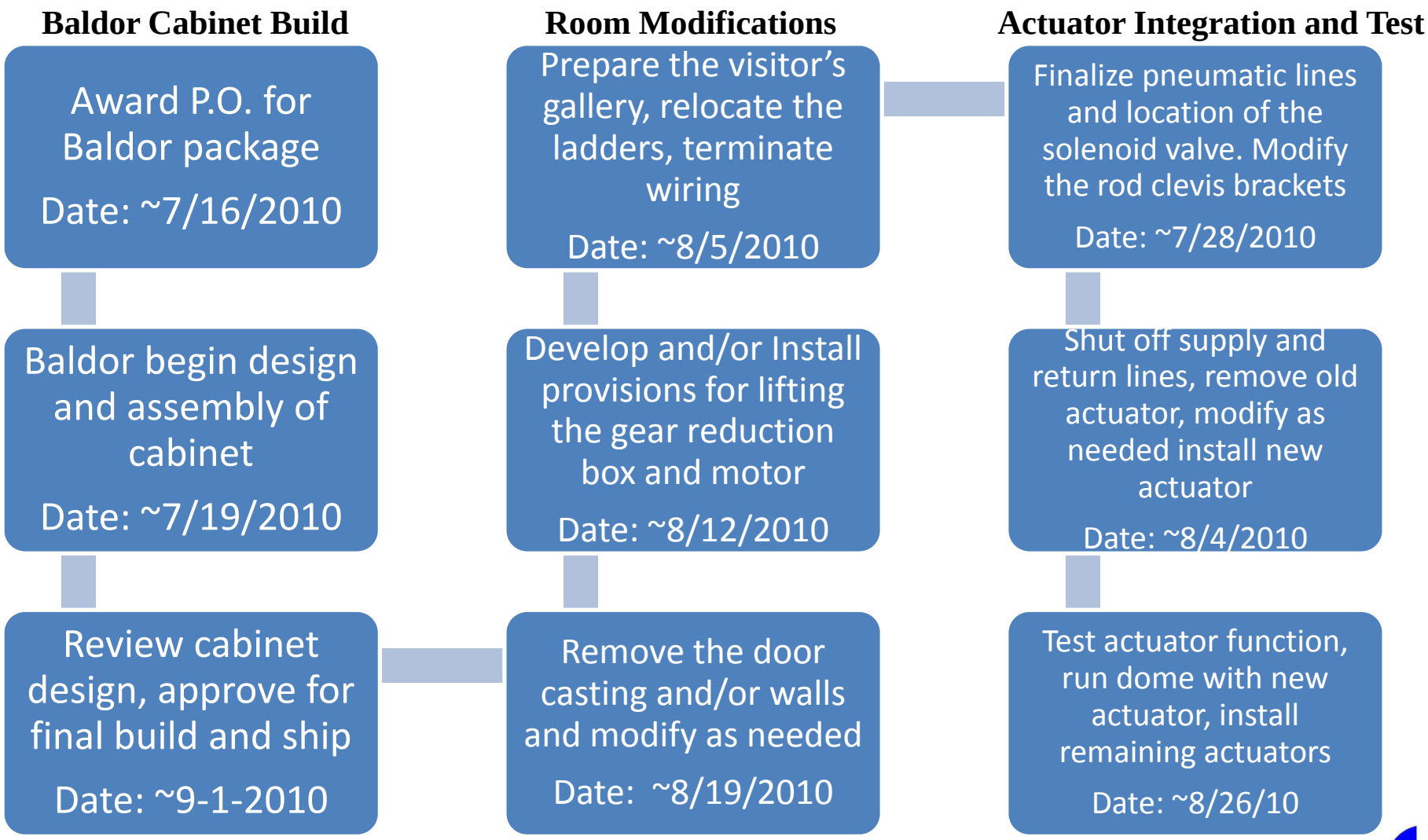
Motor Controller

- Stores data about the functionality and health of the drive system
- The Outputs can be monitored such as; speed, torque, voltage, current, etc.

Communication Method

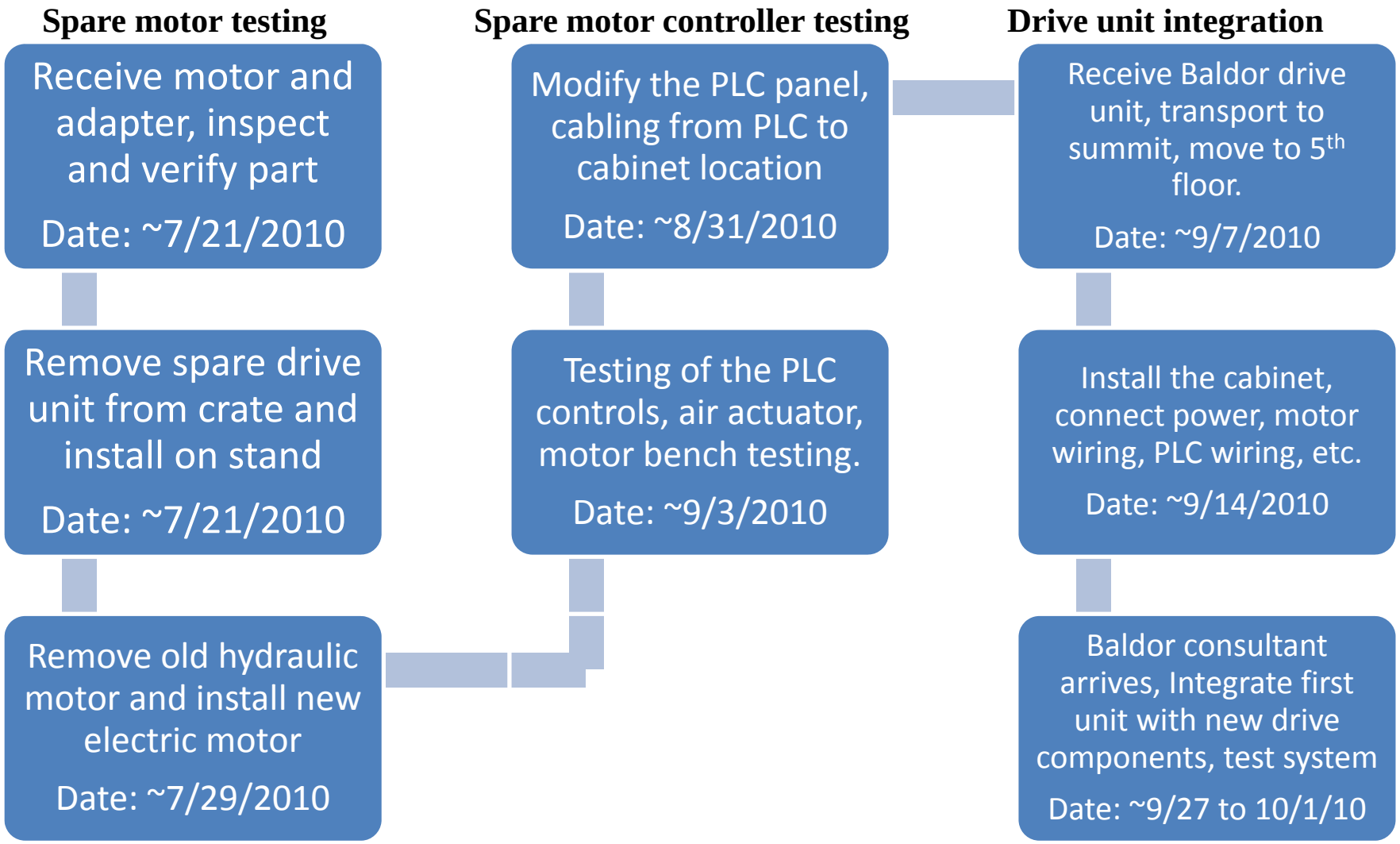
- Serial interface communication (RS232) expansion board
- Feedback information for status via and RS232 cable and Pearle device.

Time and resource estimates – Implementation plan



Some tasks can be preformed in parallel.

Time and resource estimates – Implementation plan



Some tasks can be preformed in parallel.

		Resource	Days	Description
Detailed Design Review date:		**~ July 15,2010**		
Implementation (Integration)	**Integration steps after DDR**			
	Hardware, mechanical	SB,LF	1/2	Award the purchase order for the Baldor dome drive system
	Baldor Cabinet Build			
	Hardware, mechanical	SB	1	Order Drive unit package-Place P.O. to Kaman and Baldor
		SB, Baldor	42	Baldor will begin and design the dome drive cabinet with all the components described in the proposal.
		SB, Daycrew, LR,GM		CFHT, Gary Tofanelli of Kaman, Krieg Richards and Bill Colton of Baldor will review the design make changes as needed and sign off or approve the plans for the cabinet build.
		Baldor/Kaman		The cabinet will be assembled, tested, and shipped to CFHT in 4-6 weeks by Baldor/Kaman.
	Room Modifications			
		SB, Daycrew	5	Using the footprint of the new electric motor/adapter kit combo determine what amount to remove from the upper door area.
	Hardware, mechanical			Remove the door casting and/or room walls and modify as needed in the spacer room.
				Develop and/or install provisions for lifting the 265lb gear reduction box and 290lb motor/adapter combo.
		Daycrew	1	Find a new location to relocate the ladders located in the 5th floor visitor's gallery; move them to clear space for the new cabinet.

Implementation (Integration)	**Actuator Integration and Test**			
	Hardware, mechanical	SB, Daycrew, GM	1	Inspect the actuators, clevis brackets, and pivot pins for correct model # and dimensions
				Test set-up for actuators, verify proof of concept on bench
			2	Finalize the pneumatic lines running to each dome drive unit for the actuators
				Finalize the location of the solenoid valve and plumbing on each dome drive frame
				Modify the four (4) female rod clevis brackets
			3	Record the position of the proportioning valve on the supply and return side of the actuator and valve off the actuators, record the turns needed to shut off the flow
				Remove the upper and lower pivot pins on the old hydraulic actuator
				Remove the actuator from the upper and lower brackets and place the actuator with the hydraulic lines still attached to a secure location will bungee cords
				Modify the top and bottom brackets of the drive unit frame to accommodate the new pneumatic actuator
				Install (1) one new Pneumatic Actuators actuator in the old units place, on drive unit #2
				Test pneumatic actuator function (up/down), line pressure (loss of air), and check for leaks. Remove air supply and power to actuator. See control of air actuator plan, 7.4.d)
				Run the dome drive system with (1) one pneumatic actuator in place and monitor operational differences from the hydraulic actuators
				Verification and validation of the pneumatic actuator replacement
			3	Install the remaining pneumatic actuators following the steps discussed above.
				Cap off the supply and return lines for each actuator and label accordingly. Label the actuators and store, discard, or recycle the units.

Implementation (Integration)	**Spare motor testing**			
	Hardware, mechanical	SB, Daycrew, LR	1	Receive spare electric motor and motor adapter kit.
				Inspect motor adapter kit to verify correct dimensions.
				Inspect motor to verify dimensions.
		SB, Daycrew	2	Remove the spare dome drive unit from the crate and anchor it to a suitable stand (old cute stand) for test fitting.
				Remove the hardware and hydraulic motor from the spare drive unit and annotate it with a time stamp, unit #, etc.
				Remove the hardware and adapter plate from the spare drive unit and annotate it with a time stamp, unit #, etc.
				Next unbolt the gear reduction box from the main shaft assembly and rotate it 90 degrees so the input shaft points up.
				Drain the old oil from the gearbox, record the amount removed, and recycle.
			2	Install a new breather tube or expansion tube and add required amount of oil to the gearbox.
				Install the electric motor to the new motor adapter kit.
				Mount the electric motor/adapter kit to the gear reduction box.
				Manually rotate the gear reduction box output shaft and check for smooth operation.

Implementation (Integration)	Electrical	**Spare motor controller wiring**		
		LR, Daycrew, SB	2	Install the temp circuit breaker and spare motor controller to an anchored cart or stand in the visitor's gallery.
		LR, Daycrew, SB, GM	1	Layout design for the conduit from the 4th floor to the 5th floor. 460V power
			10	Install conduit from the 4th floor electronics to the 5th floor.
			10	Pull 1 awg. Electrical wire from the 4th floor to the 5th.
			3	Run and hook up 480V power to the temp circuit breaker.
				Circuit breaker wiring check. Test wiring continuity. -Test 480V wiring connections from DP4 distribution panel to 5th floor.
				Run 480V power from the circuit breaker to the spare motor controller
				Run 8 gauge temp power conduit and cable to the test stand from the temp motor controller.
				Wire up the motor on the test stand with 8 gauge power and the feedback cable.
				Motor controller wiring check. Test wiring continuity. -Test wiring connections from temp circuit breaker to the motor controller.
				Motor wiring Check, Test wiring continuity. -power and feedback cable from the spare motor controller to spare bench motor.

Implementation (Integration)	Software and control	**Spare motor controller testing**		
			See section 7 for. implementation plan for the control of the system	
		GM	1	Modify the PLC Panel in the computer room
			1	Cabling between computer room PLC and dome drive cabinet location 5th floor.
			2	PLC code modification
			4	Integration of the controls
			3	Testing of the PLC controls
			3	Air actuator testing
			4	Motor testing
			2	Spare motor controller and spare bench motor testing complete. Awaiting Baldor cabinet for integration.
		TV, SB,GM	3	PLC communication for status monitoring
				RS232 to Perle communication for status monitoring
				Status page design
				Status/monitoring page test
Implementation (Integration)		**Drive unit motor conduit and wiring**		
	Electrical	LR, Daycrew, SB	1	Finalize the layout design (floor plan) for the conduit from the 4th floor to the 5th floor. 460V power
			2	Layout design (floor plan) for 2 sets of conduit (1/2" and ¾") for the motor power and feedback cables.
			5	Install 2 sets of conduit (1/2" and ¾") for the motor power and feedback cables.
			5	Pull 8 gauge wires for motors, i.e. electrical wire from the drive units to the drive cabinet location
			1	Motor Wiring Check, Test wiring continuity. -power and feedback cable from drive units to motor controller cabinet
		Drive cabinet integration		
	Hardware, Mechanical Electrical	SB,LF	1	Receive Baldor drive unit cabinet at HQ
		SB,RW	1	Transport the cabinet to the summit.
		SB, Daycrew	1	Install the cabinet in the 5th floor visitor's gallery and secure it in place.
		LR	1	Connect 1awg wiring to the drive unit. Test functionality
		LR, Daycrew, SB, GM		Motor controller wiring check. Test wiring continuity. -Test wiring connections from circuit breaker and PLC to the motor controller.
		LR, SB, Daycrew	1	Finish motor controller cabinet install and checkout.

Implementation (Integration)	Hardware, Mechanical Electrical	**Drive unit Integration**		
		SB, Daycrew	2	Hydraulic motor retrofit can begins a few days before the cabinet is delivered or once the cabinet is integrated
				Remove hardware, old hydraulic motor, and adapter kit from drive unit #2.
				Remove hardware and rotate the Brevini gearbox 90 degrees so the input shaft is up.
				Assemble the new adapter kit/electric motor combination.
				Install new assembly to the Brevini gear reduction box on drive unit #2
		WC, GM, SB	4	TCS/PLC/cabinet Testing with new electric drive unit #2
		SB, Consultant	1	Motor controller consultant arrives on island (this can occur before the first unit is integrated or after)
		SB, Daycrew, WC, GM, Consultant	2	Dome drive Consultation Commissioning and Testing-Begin day testing of VFD system.
				Test drive unit # 2 under electric motor control
		SB, Daycrew	1	Prefer to perform Unit #3 retrofit when F/8 is on telescope
				Remove old hydraulic motor and adapter kit from drive unit #3
				Rotate Brevini gearbox 90 degrees
				Install new Brevini adapter kit on drive unit #3
				Install new Electric motor on drive unit # 3
		SB, Daycrew, WC, GM, Consultant	2	Test drive unit # 2 and 3 under electric motor control.
				New electric drive system Commissioned and ready for nightly operations-under two drive unit operations temporarily.
		SB, Daycrew	3	Remove old hydraulic motor and adapter kit from drive unit #1
				Rotate Brevini gearbox 90 degrees
				Install new Brevini adapter kit on drive unit #1
				Install new Electric motor on drive unit # 1
				See section 7 for. implementation plan for the control of the system
	Software, Electrical	SB, GM, WC, Daycrew	5	Test drive unit # 1, 2 and 3 under electric motor control.
			1	Manual/automatic system tests
			3	Phase 1 Finished- Dome drive system now under electric drive system control.

Equipment and Material Costs					
Item	Qty	Component description	Cost	Total	Notes/Includes:
1	1	Baldor ZD22H420EL drive panel package proposal	$43,860.53	$43,860.53	Drive system package, 3X motor controllers and equipment needed to assemble drive cabinet, for more information.
2	3	Baldor 20HP RPM AC ZDFRPM21204C motor	$3,096.00	$9,288.00	Drive system motors, 3X motors. 1 Master and 2 Slaves, for more information.
3	1	Baldor-spare 20HP RPM AC ZDFRPM21204C motor	$3,096.00 *Shipping: *$243.37	$3,339.38	Spare drive system motor, special pricing when purchased as a package, for more information.
4	1	Baldor-spare ZD22H425EL motor controller	$8,660.00 *Shipping: *$243.37	$8,903.38	Spare drive system motor controller, special pricing when purchased as a package, for more information.
5	1	Baldor applications engineer for drive commissioning	$5000.00	$5000.00	Plus travel expenses, i.e. airfare, lodging, rental car.
6	1	HFB3150-R, 150amp 600 volt 3 pole circuit breaker	$650.00 *Shipping: *$69.45	$719.45	Southland Electrical Supply, for more information
7	1	Gexpro-Electrical conduit and wiring upgrades	$3,868.84	$3,868.84	New 1awg wiring and conduit run from the 4th floor to the 5th floor, 8 gauge wire and conduit for the motor power runs, for more information
8	4	*Parker Hannifin* Pneumatic actuators for the dome drive frames	$623.67	$2,530.68	Includes: four (4) Pneumatic actuators, (1) one is a spare, for more cost information.
10	4	*Parker Hannifin* *Female* Rod clevis brackets for the dome drive frames	$50.95	$203.80	Includes: Four (4) Female rod clevis, (1) one is a spare, for more cost information.
11	4	*Parker Hannifin* Pivot pins for the dome drive frames	$21.85	$87.40	Includes: four (4) Pivot pins, (1) one is a spare, for more cost information.
12	4	Pneumatic Solenoid valves, air lines, and fittings	$655.00	$2,620.00	Includes: four (4) Solenoid valves, (1) one spare, for more cost information.
13	4	Brevini Motor adapter kits-qty 4	$606.70	$ 2,426.80	Includes (4) motor adapter kits, (1) one spare kit, for more cost information.
14	1	Heat mitigation • Option1: Vent cabinet into the visitors gallery • Option 2: Fan above the stair access door • Option 3:Heat exchanger with glycol lines and fittings	$1,500.00	$1,500.00	❖ This is the cost for the third option in the heat mitigation. ❖ The second option will cost around $600.00 ❖ Option 1 has no added costs
		Misc materials and supplies		$1,000.00	
			TOTAL	$85,348.26	

Any Additional Questions or Comments?

Thank you for your time!