

**Translated system requirements into PTO**  
**design requirements (in addition to**  
**component-level metrics)**  
**(Protected Rights Data)**

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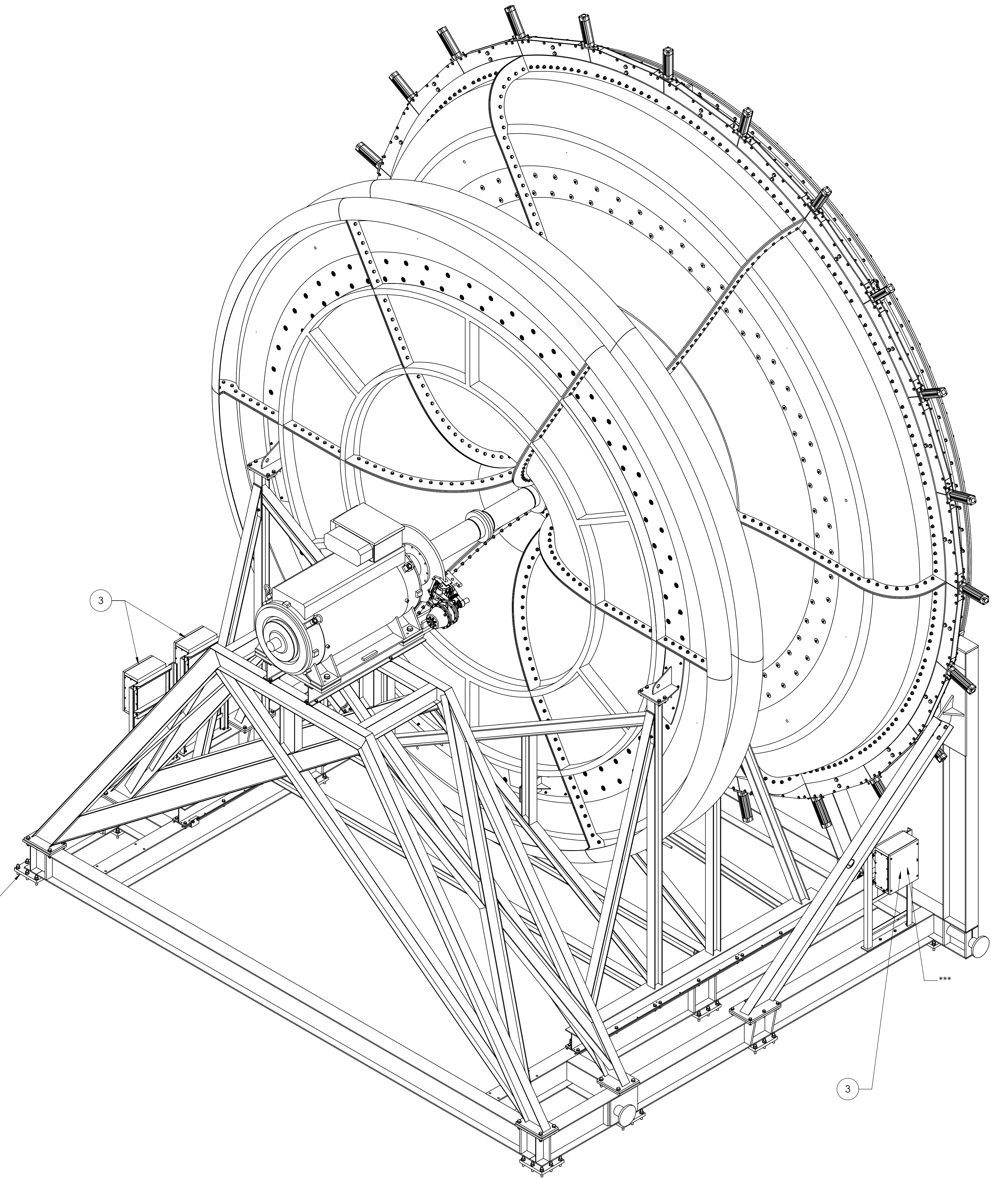
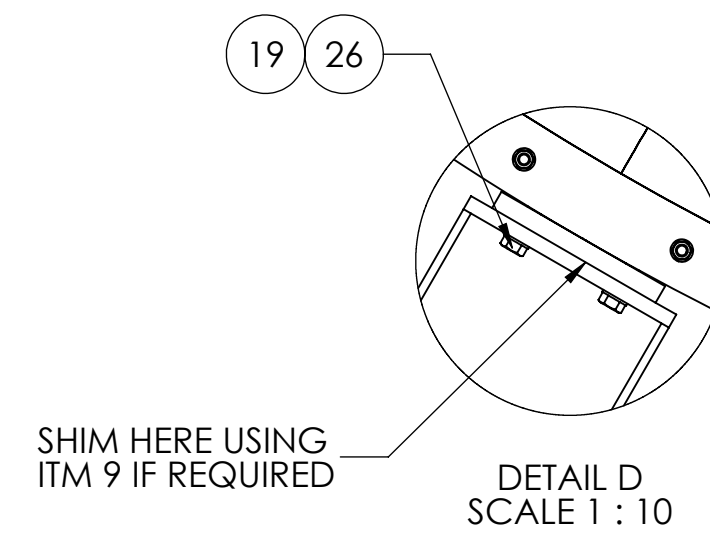
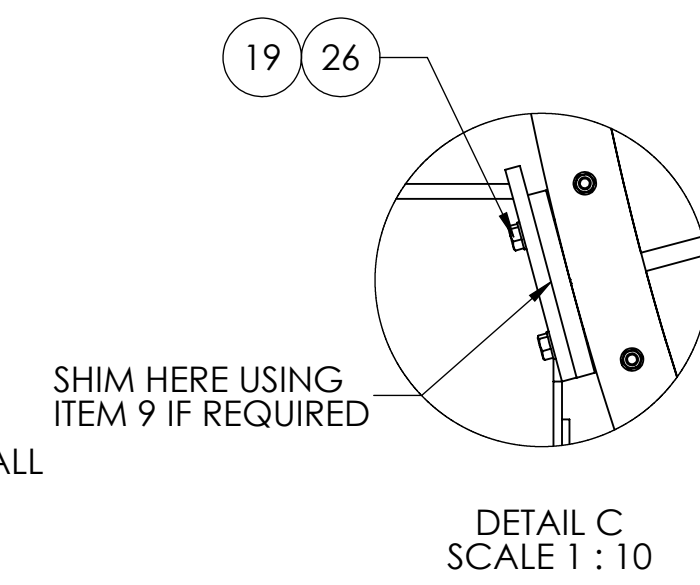
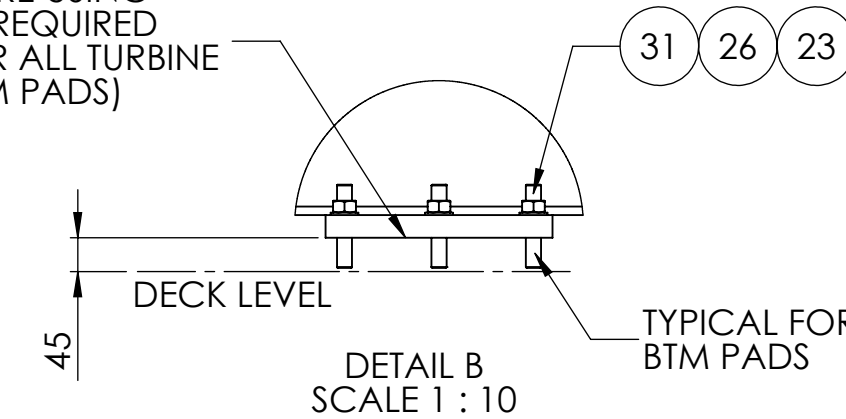
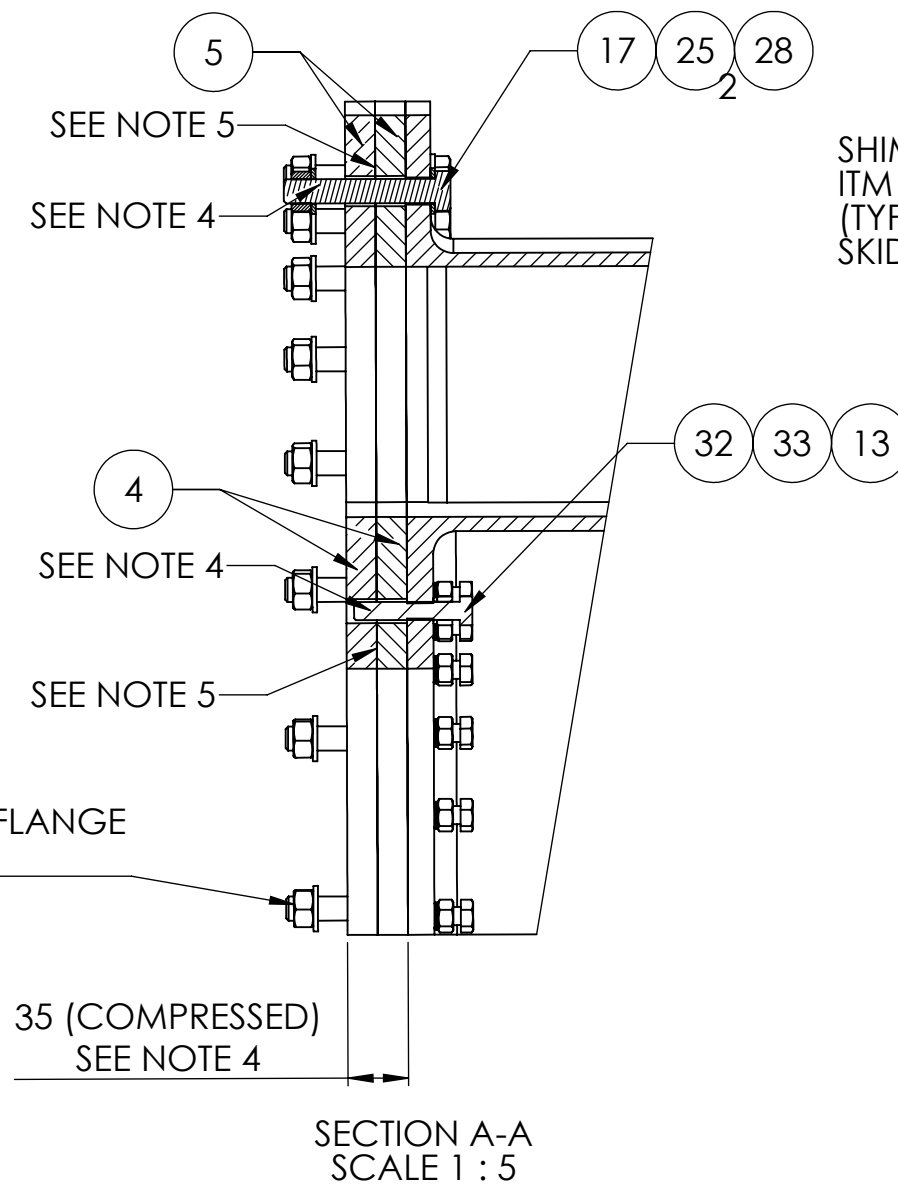
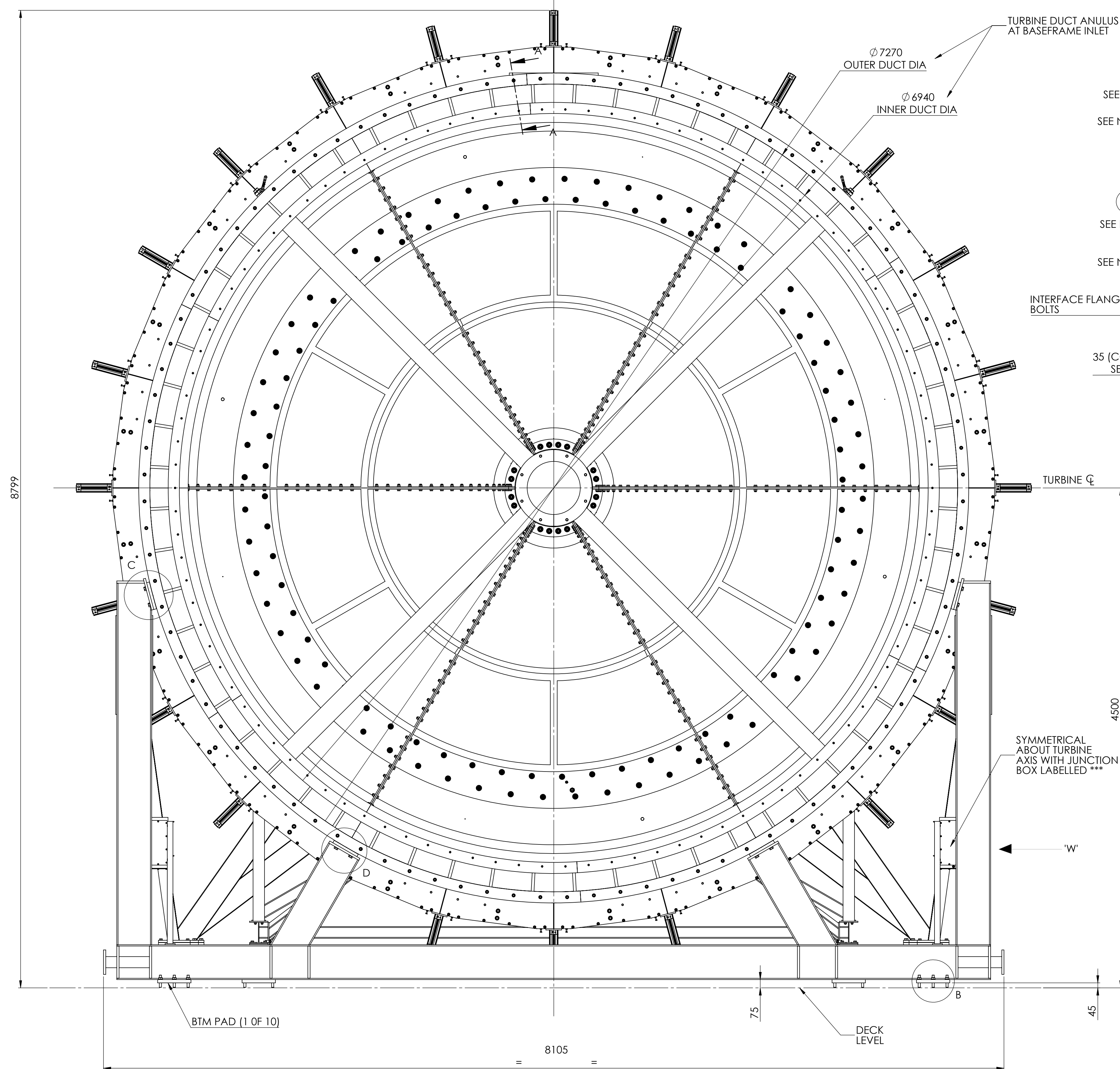
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### **Maximum cost**

Project and site Specific, and depends on performance targets. For current project costs, please refer to Budgetary / Cost Estimate in subsequent Sections.

### **Critical dimensions and weights**



|      |                                                 |      |       |               |                  |       |
|------|-------------------------------------------------|------|-------|---------------|------------------|-------|
| 32   | M12 NUT                                         | 98   |       | GR A2         | MR-C-001-090-003 |       |
| 32   | M12 SPRING WASHER                               | 98   |       | GR A2         | MR-C-001-136-003 |       |
| 31   | M20 x 110LG STUD                                | 56   |       | GR A2-70      | MR-C-001-234     |       |
| 30   | 3M RUBBER AND VINYL 80 SPRAY ADHESIVE           | 1    |       |               | MR-C-001-220     |       |
| 29   | LOCITITE 243                                    | 1    |       |               | MR-C-001-135     |       |
| 28   | M16 BHNX NUT                                    | 96   |       | 303 ST STL    | MR-C-001-219     |       |
| 27   | M30 WASHER                                      | 8    |       | GR A2         | MR-C-001-089-006 |       |
| 26   | M20 WASHER                                      | 96   |       | GR A2         | MR-C-001-089-005 |       |
| 25   | M16 WASHER                                      | 227  |       | GR A2         | MR-C-001-089-004 |       |
| 24   | M30 NUT                                         | 4    |       | GR A2         | MR-C-001-090-006 |       |
| 23   | M20 NUT                                         | 64   |       | GR A2         | MR-C-001-090-005 |       |
| 22   | M16 NUT                                         | 19   |       | GR A2         | MR-C-001-090-004 |       |
| 21   | M30 x 120 LG HEX HD BOLT                        | 4    |       | GR A2-70      | MR-C-001-093-011 |       |
| 19   | M20 x 55 LG HEX HD BOLT                         | 24   |       | GR A2-70      | MR-C-001-092-005 |       |
| 18   | M20 x 40 LG HEX HD BOLT                         | 8    |       | GR A2-70      | MR-C-001-092-007 |       |
| 17   | M16 x 100 LG HEX HD BOLT                        | 96   |       | GR A2-70      | MR-C-001-093-012 |       |
| 16   | M16 x 100 LG SKT HD CAPSCREW                    | 2    |       | GR A2-70      | MR-C-001-091-012 |       |
| 15   | M16 x 80 LG SKT HD CAPSCREW                     | 70   |       | GR A2-70      | MR-C-001-091-011 |       |
| 14   | M16 x 60 LG HEX HD BOLT                         | 16   |       | GR A2-70      | MR-C-001-093-009 |       |
| 13   | M12 x 70 LG HD HEX HD BOLT                      | 98   |       | GR A2-70      | MR-C-001-092-009 |       |
| 12   |                                                 |      |       |               |                  |       |
| 11   | CALIPER SHIMS                                   | 1    |       |               | MR-C-001-216     |       |
| 10   | DUCT BRACKET SHIMS                              | 1    |       |               | MR-C-001-214     |       |
| 9    | BASE FRAME PAD SHIMS                            | 1    |       |               | MR-C-001-213     |       |
| 8    | GENERATOR FEET SHIMS                            | 1    |       |               | MR-C-001-212     |       |
| 7    | TURBINE SKID FEET SHIMS                         | 1    |       |               | MR-C-001-211     |       |
| 6    | DUCT ASSEMBLY TO DUCT FRAME BRACKET             | 4    |       |               | MR-C-001-209     |       |
| 5    | BASEFRAME/CHAMBER OUTER FLANGE INTERFACE GASKET | 12   |       |               | MR-A-001-207     |       |
| 4    | BASEFRAME/CHAMBER INNER FLANGE INTERFACE GASKET | 12   |       |               | MR-A-001-206     |       |
| 3    | JUNCTION BOX ASSEMBLY                           | 4    |       |               | MR-A-001-222     |       |
| 2    | GENERAL ASSEMBLY                                | 1    |       |               | MR-A-001-126     |       |
| 1    | INTERFACE AND SUPPORT STRUCTURE ASSEMBLY        | 1    |       |               | MR-A-001-198     |       |
|      | COMPLETE TURBINE AND INTERFACE ASSEMBLY         | 1    |       |               | MR-A-001-210     |       |
| ITEM | DESCRIPTION                                     | QTY. | MATL. | MATL. & SPEC. | ITEM NO/ DWG NO  | LEVEL |

NOTES:

1. GENERATOR AND ROTOR SHAFT TO BE ALIGNED FOLLOWING COUPLING MANUFACTURERS INSTRUCTIONS
2. ITEM 29 LOC'TITE 243 TO BE APPLIED TO FASTENERS EXCEPT INTERFACE FLANGE BOLTS AND BNX NUTS (SEE SECTION A-A)
3. ALL FASTENERS TO BE TORQUED TO THE FOLLOWING SCHEDULE UNLESS OTHERWISE SPECIFIED
 

| THREAD SIZE | TORQUE VALUE (Nm) |
|-------------|-------------------|
| M10         | 38                |
| M12         | 66                |
| M16         | 180               |
| M20         | 333               |
| M30         | 670               |
4. INTERFACE GASKETS TO BE COMPRESSED BY 5mm (NOMINAL 40mm THK) BY TIGHTENING ITEMS 17 & 28 UNTIL DISTANCE BETWEEN BASE FRAME FLANGE AND PLENI FLANGE IS 35mm. ITEMS 13 & 33 TO BE PROVISIONALLY SET TO 35MM
5. BOTH LAYERS OF INNER AND OUTER INTERFACE GASKET ITEMS 4 & 5 TO BE GLUED TOGETHER IN POSITION USING ITEM 30 3M RUBBER AND VINYL 80 SPRAY ADHESIVE FOLLOWING MANUFACTURERS INSTRUCTIONS
6. FOR DETAILS OF DECK MOUNTING PAD POSITIONS SEE TURBINE SKID MR-A-001-199
7. APPROX MASS: 22000 KG

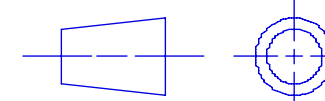
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|-------------|----------------------|
| M10         | 38                   |
| M12         | 66                   |
| M16         | 180                  |
| M20         | 333                  |
| M30         | 670                  |

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| TOLERANCE LIMITS UNLESS OTHERWISE SPECIFIED |                 |             |  |
|---------------------------------------------|-----------------|-------------|--|
| TYPE                                        | 150mm AND Below | ABOVE 150mm |  |
| MACHINING                                   | +/- 0.5mm       | +/- 1.0mm   |  |
| FABRICATION                                 | +/- 0.5mm       | +/- 1.0mm   |  |
| ANGULARITY                                  | +/- 1           | +/- 1       |  |

View Projection



|                   |              |
|-------------------|--------------|
| DRAWN: A.E<br>K.O | DATE: 24MAY1 |
|-------------------|--------------|

|                       |              |
|-----------------------|--------------|
| CHECKED: R.H.<br>M.K. | DATE: 24MAY1 |
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|                |              |
|----------------|--------------|
| APPROVED: S.N. | DATE: 24MAY1 |
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**DRESSER-RAND**

A Siemens Business

FRAME DATA: RADIAL HAT 1.65D

TITLE: COMPLETE TURBINE &  
INTERFACE ASSEMBLY

|      |      |         |
|------|------|---------|
| SIZE | DEF. | TIME MS |
|------|------|---------|

|    |              |
|----|--------------|
| A0 | MR-A-001-210 |
|----|--------------|

|      |     | REVISION HISTORY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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                                                                                                                 |  | DATE | APP |
|      |     | GENERAL DIMENSIONS ADDED: ITEM 4 ALTERED, ITEM 7 INSERTED<br>ITEM 3 ADDED, ITEMS 8 & 9, MEASUREMENTS X 96-5-GR-007<br>DESCRIPTION CHANGED: ITEM 19 WAS MISC 001-095-008 NOW 005, ITEM 20 REMOVED, LGX HD BOLT, ITEM 21 MIX X 96-5-GR-007<br>ITEM 22 WENT W/ITEM 21, ITEM 23 WENT W/ITEM 21, ITEM 24 WENT W/ITEM 21<br>ITEM 25 WENT W/ITEM 21, ITEM 26 WENT W/ITEM 21, ITEM 27 WENT W/ITEM 21<br>ITEM 28 WENT W/ITEM 21, ITEM 29 WENT W/ITEM 21, ITEM 30 WENT W/ITEM 21<br>ITEM 31 WENT W/ITEM 21, ITEM 32 WENT W/ITEM 21, ITEM 33 WENT W/ITEM 21<br>ITEM 34 WENT W/ITEM 21, ITEM 35 WENT W/ITEM 21, ITEM 36 WENT W/ITEM 21<br>ITEM 37 WENT W/ITEM 21, ITEM 38 WENT W/ITEM 21, ITEM 39 WENT W/ITEM 21<br>ITEM 40 WENT W/ITEM 21, ITEM 41 WENT W/ITEM 21, ITEM 42 WENT W/ITEM 21<br>ITEM 43 WENT W/ITEM 21, ITEM 44 WENT W/ITEM 21, ITEM 45 WENT W/ITEM 21<br>ITEM 46 WENT W/ITEM 21, ITEM 47 WENT W/ITEM 21, ITEM 48 WENT W/ITEM 21<br>ITEM 49 WENT W/ITEM 21, ITEM 50 WENT W/ITEM 21, ITEM 51 WENT W/ITEM 21<br>ITEM 52 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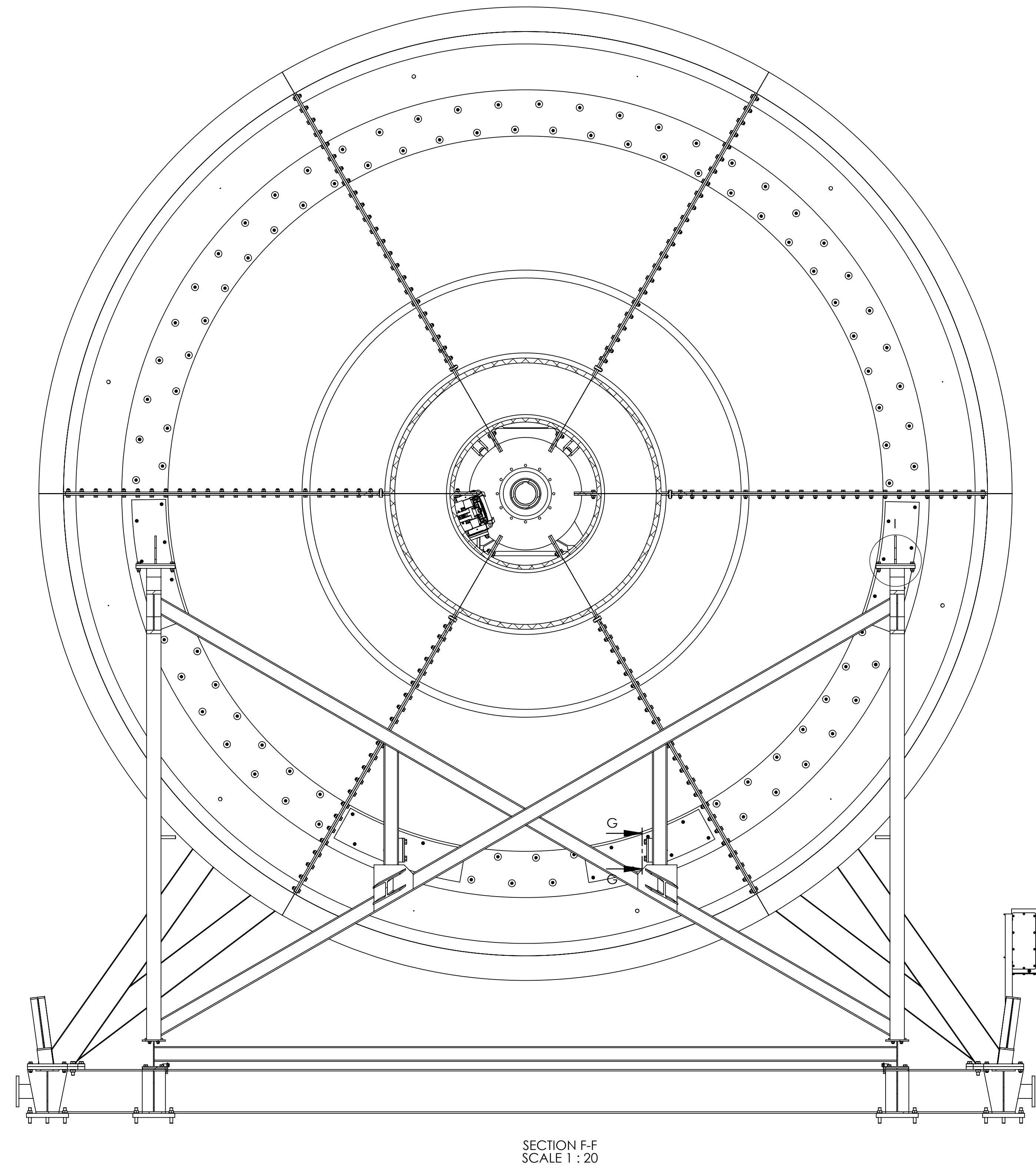
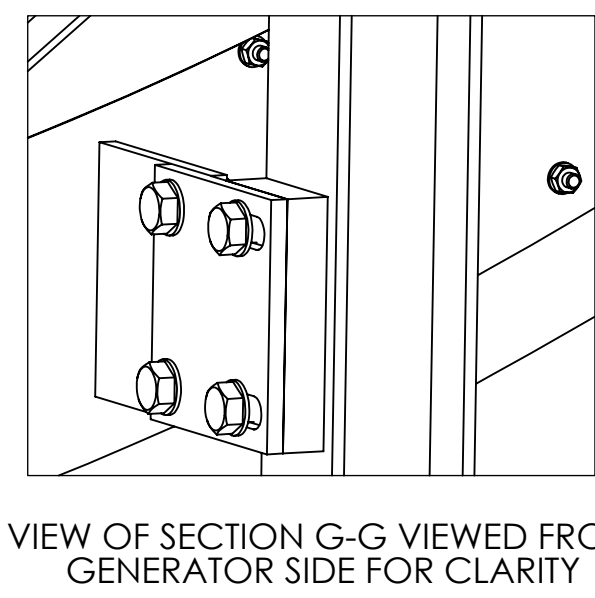
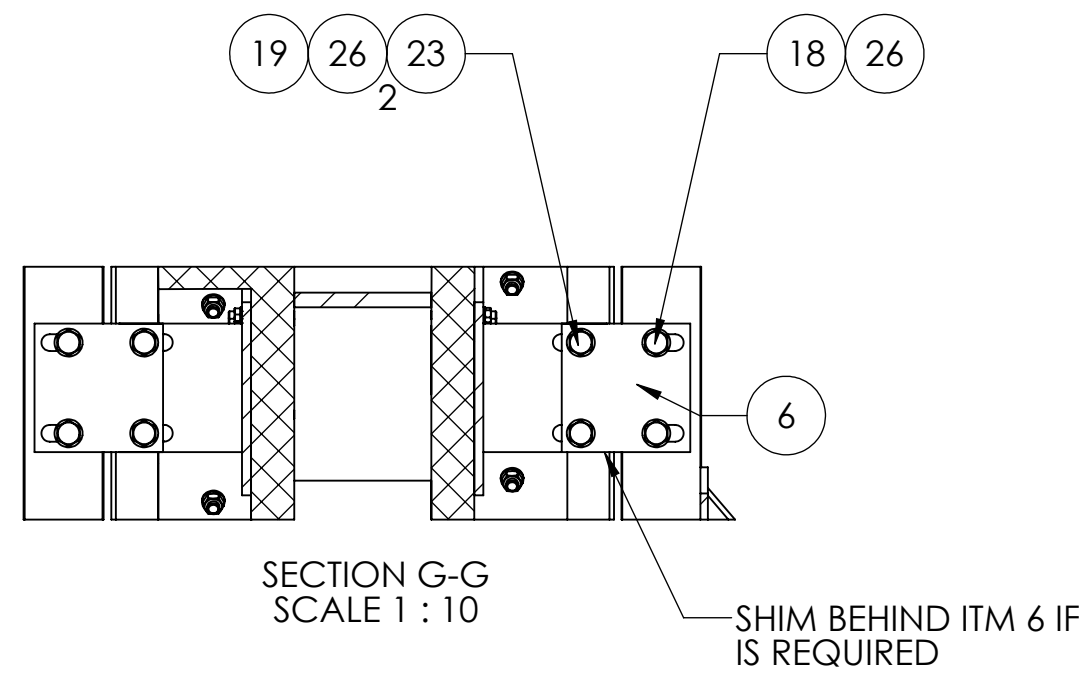
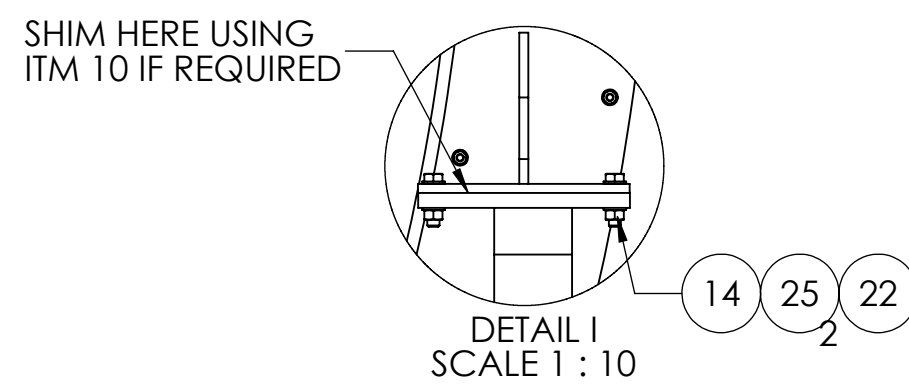
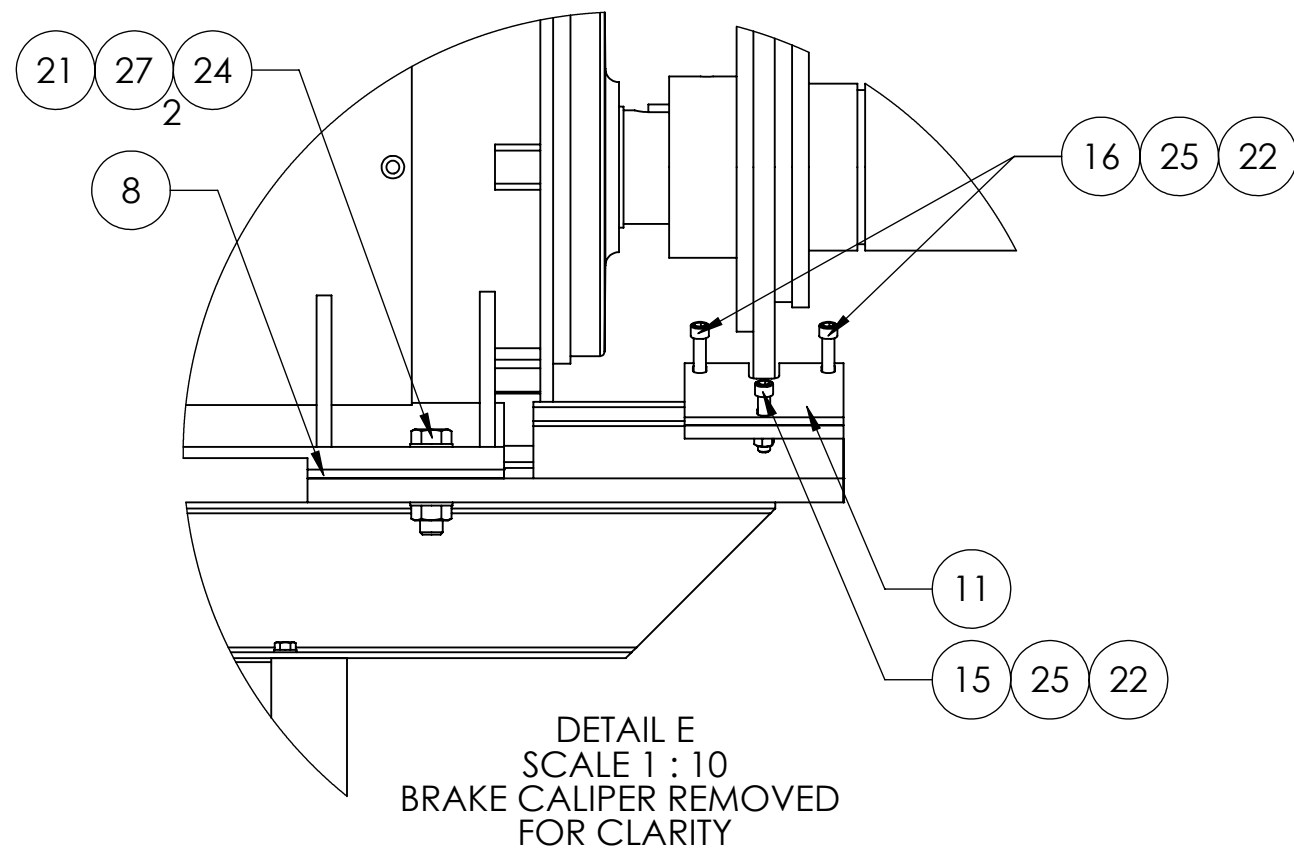
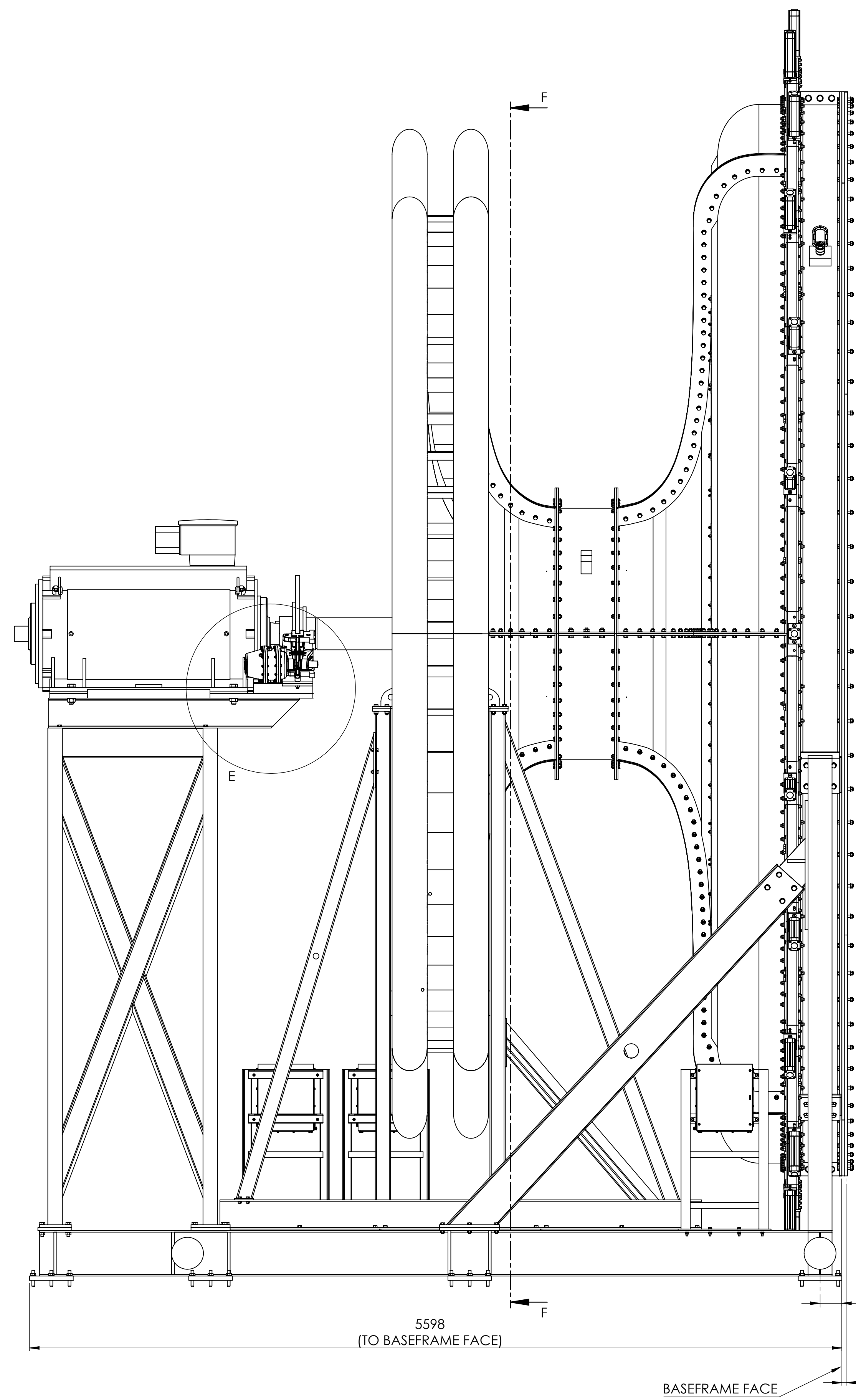
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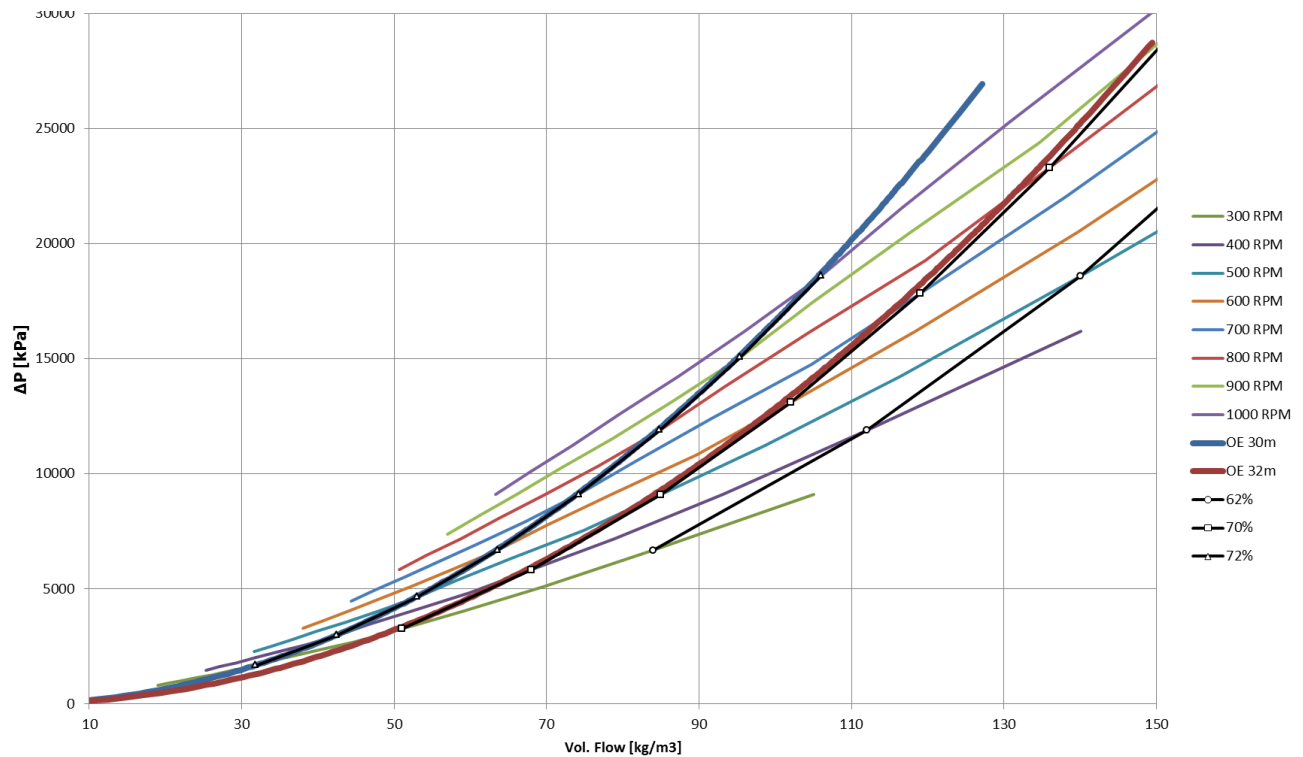


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| FRAME DATA: RADIAL HAT 1.65D                       |      |                         |              |
| TITLE:<br>COMPLETE TURBINE &<br>INTERFACE ASSEMBLY |      |                         |              |
| SIZE<br>A0                                         | REF: | DWG NO.<br>MR-A-001-210 | REV:<br>02   |
| SCALE:                                             |      | WT:                     | SHEET 2 OF 2 |

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

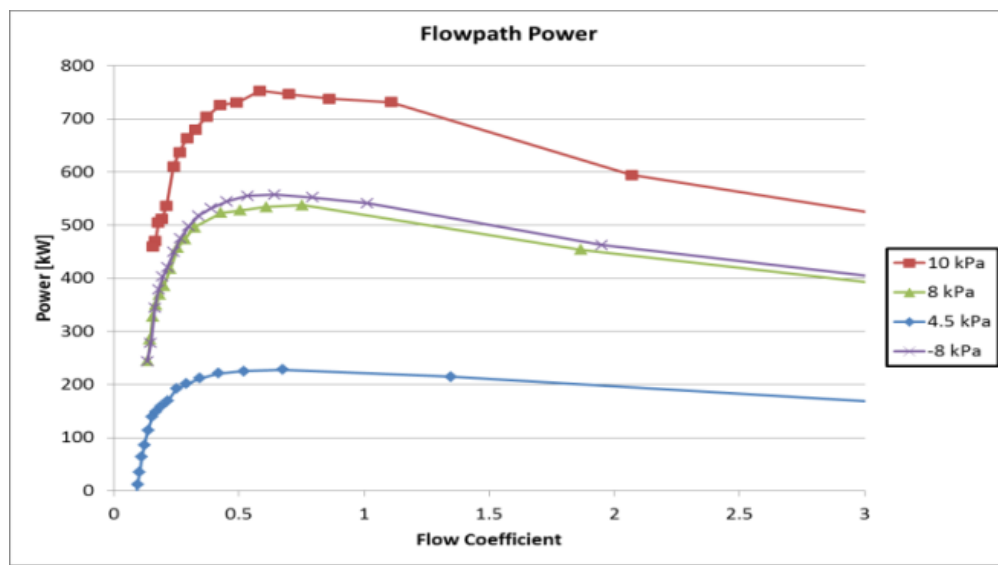
## Damping Curve



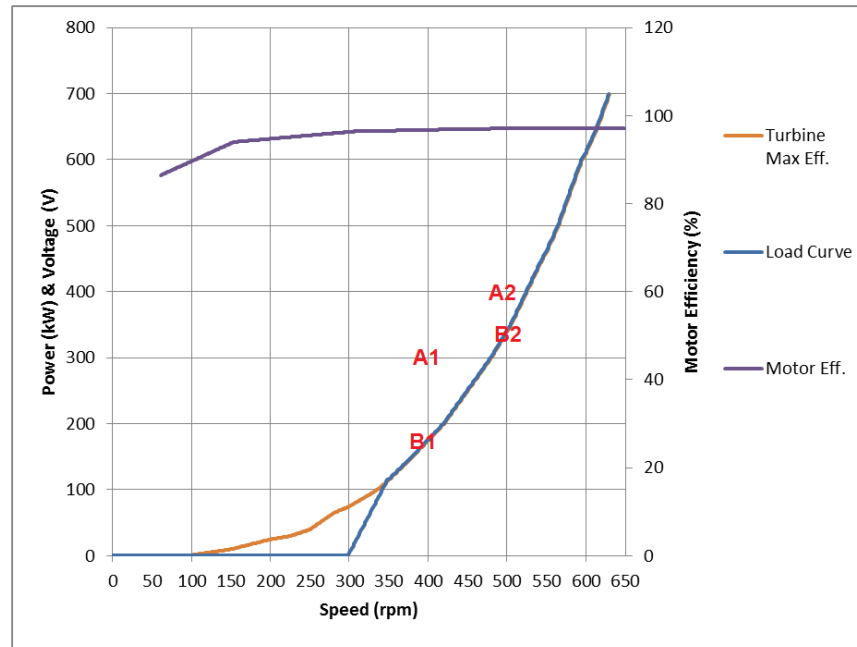
## Rotor speed profile changes

For the selected geometry of 1.65 meter rotor diameter, the turbine will have an operating band of 300-800RPM with a maximum speed of 1,000 RPM,

## Mechanical power for a given pressure and airflow



## Turbine rpm range and power

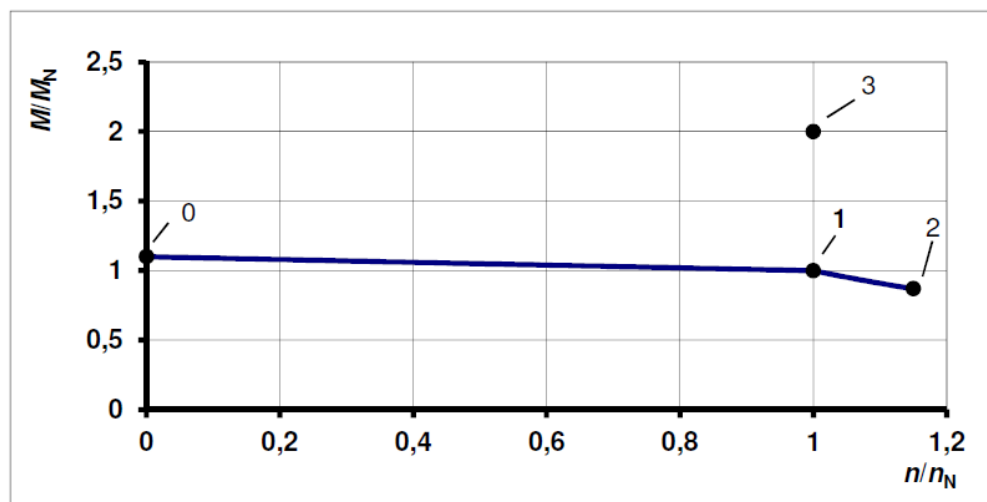


## Generator input torque

### Operating and Installation Data:

|              |                  |           |
|--------------|------------------|-----------|
| Rated-       |                  |           |
| -power       | $P_N$ :          | 500 kW    |
| -voltage     | $U_N$ :          | 690 V     |
| -frequency   | $f_N$ :          | 86.7 Hz   |
| -current     | $I_N$ :          | 455 A     |
| -speed       | $n_N$ :          | 650 1/min |
| -torque      | $M_N$ :          | 7346 Nm   |
| Power factor | $\cos \varphi$ : | 0.95      |

## Torque speed curves/profile



## Generated electrical power for given input torque

|         |                       | 0    | 1           | 2    | 3     |
|---------|-----------------------|------|-------------|------|-------|
| Torque  | $M / \text{Nm}$       | 8080 | <b>7346</b> | 6366 | 14700 |
| Speed   | $n / \text{min}^{-1}$ | 0    | <b>650</b>  | 750  | 650   |
| Power   | $P / \text{kW}$       | 0    | <b>500</b>  | 500  | 1000  |
| Voltage | $U / \text{V}$        | 6    | <b>687</b>  | 690  | 690   |
| Current | $I / \text{A}$        | 490  | <b>453</b>  | 435  | 950   |

## Generator Load Cycles

### Calculated Partial Load Data:

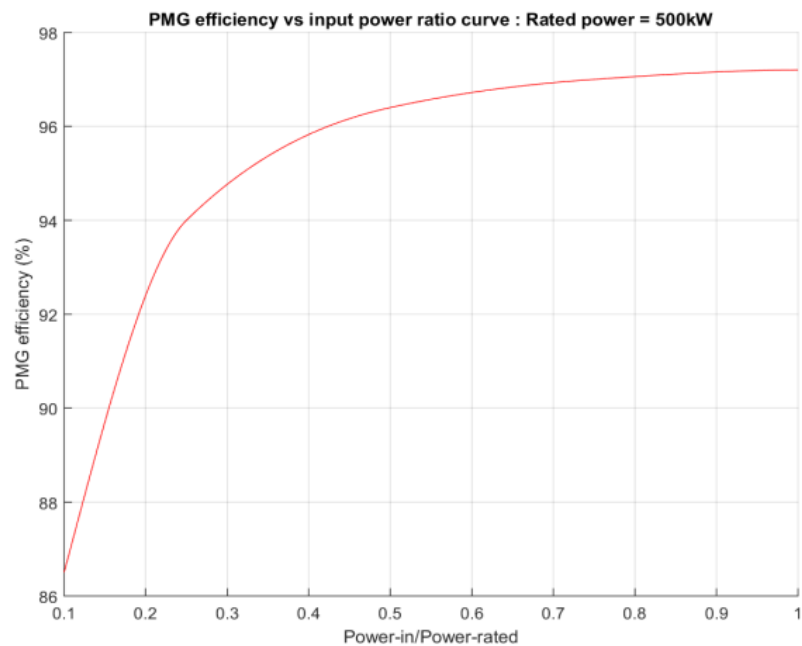
|                   |      |      |      |      |       |
|-------------------|------|------|------|------|-------|
| $P/P_N$           | 1.00 | 0.75 | 0.50 | 0.25 | 0.10  |
| $\cos \varphi$    | 0.95 | 0.97 | 0.98 | 0.99 | ~1.00 |
| $\eta \quad [\%]$ | 97.2 | 97.0 | 96.4 | 94.0 | 86.5  |

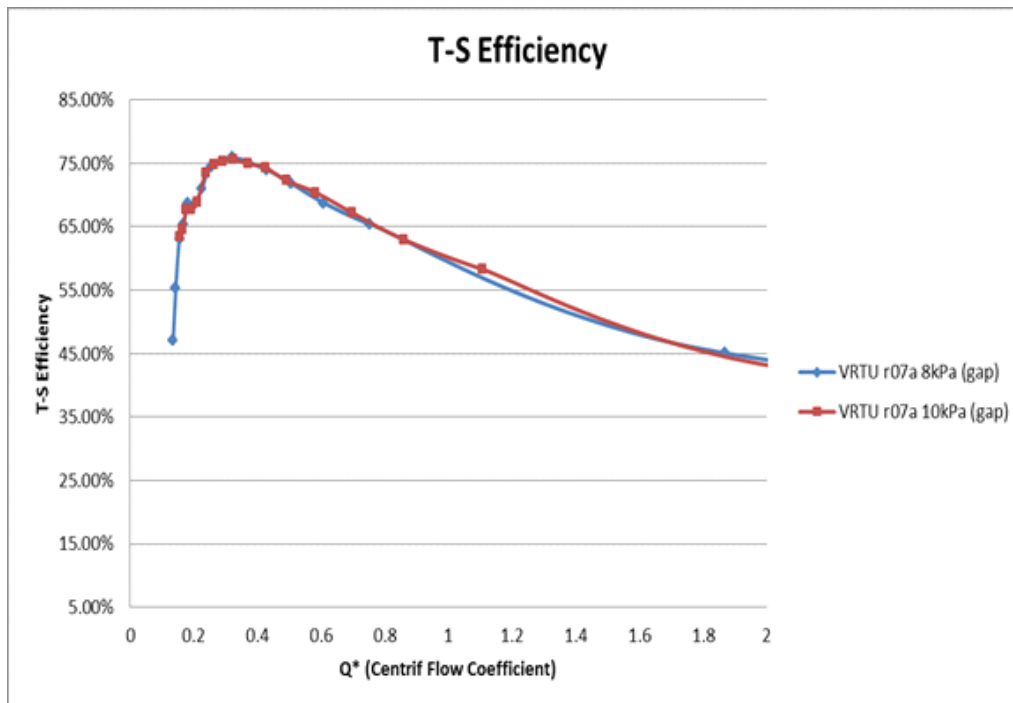
Efficiency  $\eta > 97.0\%$  for rated torque within speed range 350 - 750rpm

## Variation in generator speed

See Generator Input Torque

## Conversion efficiencies for pressure to mechanical; mechanical to electrical; and losses due to conditioning





### **Generator temperature**

Class of rating : S1  
Absolute altitude : <1000 m ab.s.l.  
Coolant temperature : 38 °C  
Water (l/min) : 30  
Therm. class (design/util.) : 155 (F) / 130 (B)

### **Vibration/acceleration**

| Parameter         | Quantity        | Measurement<br>Range                                   | Accuracy | comments       |
|-------------------|-----------------|--------------------------------------------------------|----------|----------------|
| Bearing Vibration | 2 (X,Y<br>axes) | Acceleration:<br>frequency<br>response 3 -<br>10000 Hz | 2%       | 4-20 mA output |

### **Operating angle**

N/A

### **Shaft strain**



### **Noise level**

Noise attenuation: sound levels of HAT <100 dBa, due to low running speed of shaft

### **Power (power quality)**

Refer to grid requirements document under Specified System Requirements document

### **Electrical outputs from generator (pre-frequency converter) Voltage, current, and frequency**

|            |         |         |
|------------|---------|---------|
| -voltage   | $U_N$ : | 690 V   |
| -frequency | $f_N$ : | 86.7 Hz |
| -current   | $I_N$ : | 455 A   |

### **Power conditioning requirements between generator output and grid connection**

See Power (power quality)

### **Control system (controlling electrical load) requirements**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                   |                                                                                                                                                                                                                                            |             |
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## PLC CONTROL SYSTEM

### BASIC DESCRIPTION

The Converter Control & Interfacing Unit (CCI), is the master control system for the Power Takeoff system. The CCI's function is to process the sequential control logic program, to provide the visualization, operator interface, alarm and fault annunciation, as well as technological control referencing of the system and to monitor and control the auxiliary systems on the platform. The CCI will also provide for interfacing to higher-level control systems in the future.

The CCI manages the communication between the control components of the system.

For example:

- Start stop control signals and reference values to the inverter
- Inverter status and operating values to the PLC and HMI
- Operator inputs from the HMI to the PLC
- System status and monitoring feedback from the PLC to the HMI
- Operator feedback from the Inverter and power monitor to the HMI

The CCI is composed of a Simatic S7 1500 PLC, a Simatic TP1200 Comfort panel HMI, and a Scalance X308-2 Ethernet switch.

The PLC is the sequential logic control system and communications master. It controls the communications between all controllers, the HMI and any upper level control or SCADA systems. The PLC sends control signals to the controllers and poles the controllers and the

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power meter to collect the available process data. The Process data is stored in the PLC and made available for display on the HMI.

The PLC processes sequential logic program, monitoring the status of the equipment and based on the programmed logic allows the system to be started or to continue to operate. The controller will be programmed to administer the permissive and fault and alarm logic, as well as technological control referencing of the system and to monitor and control the auxiliary systems on the platform.

The Human Machine Interface is an integral component of the CCI. It will consist of a TP1200 12in panel mounted display, programmed with 4 screen views to except and display operational parameters and alarm and fault messages. The operation screen can display such as system variables as; operational status, power, current, voltage, component temperatures etc.

The Ethernet network switch is an integral component in the CCI, providing the means for the systems to communicate operator commands, reference values and process data amongst the control computers.

## EQUIPMENT COMPRISING THE SYSTEM

### EQUIPMENT SELECTED

- 1) Simatic S7 1500 Series PLC
- 2) Simatic WinCC Comfort PLC
- 3) Scalance X300 Series Ethernet switch

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                   |                                                                                                                                                                                                                                            |             |
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## COMMUNICATIONS SYSTEM

### SYSTEM OVERVIEW

ProfiNet has been selected as the primary backbone of the communications system. The communications system links the following system components:

- Ethernet Switch
- PLC (Master)
- HMI
- Active Line Module
- Motor Modules (Inverters)
- Power Meter

The Ethernet switch is a Scalance X300 it forms a star point in the network. This switch will handle the routing of all traffic on the network. The onboard media will be copper and the unit to shore media will be single mode fiber.

The PLC is the sequential logic control system and communications master. It controls the communications between all controllers, the HMI and any upper level control or SCADA systems. The PLC sends control signals to the controllers and poles the controllers and the power meter to collect the available process data. The Process data is stored in the PLC and made available for display on the HMI.

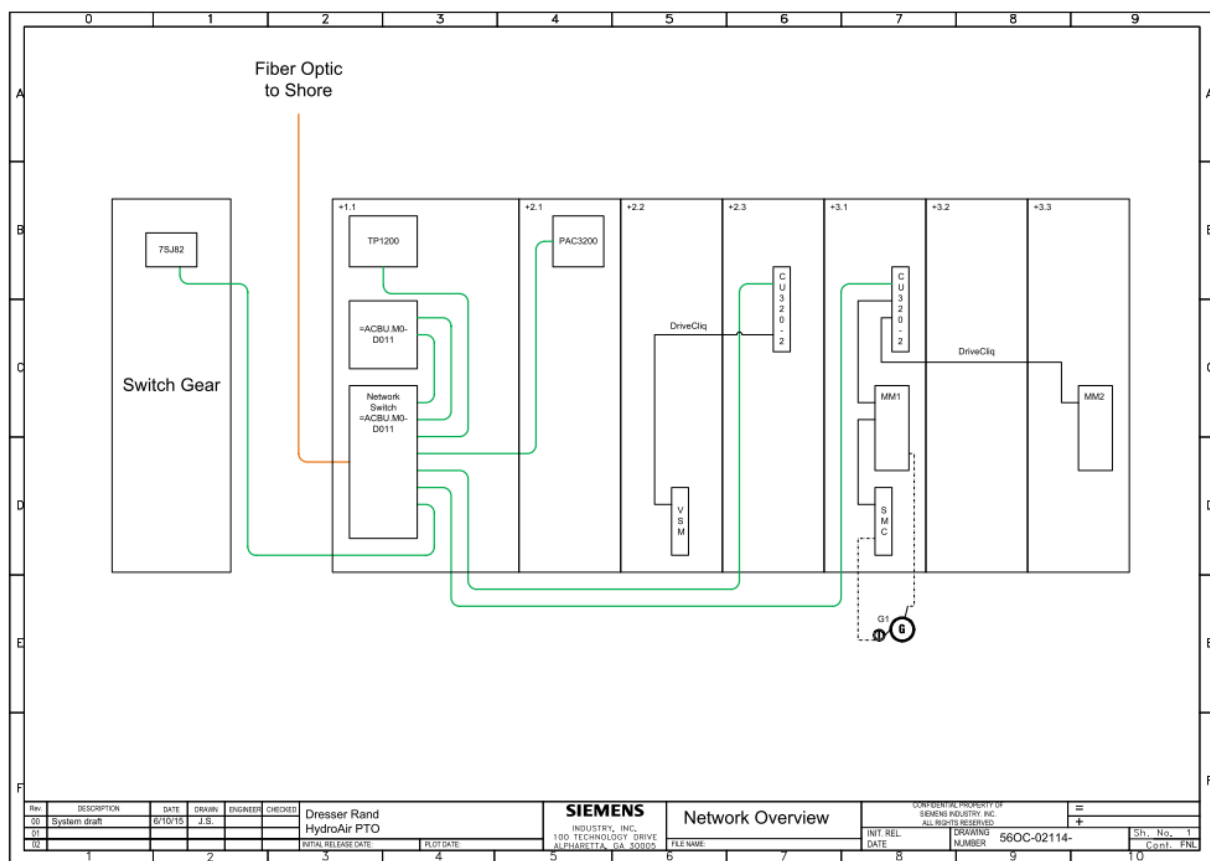
The Active Line module controls the DC Bus Voltage of the inverter System.

There are two Motor Modules one to control the power take off from the PMG HAT system and one to reject excess power that could not be fed back to the line due to problems with the ALM.

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The Power Meter continually measures power system values and makes this information available on the network.



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**Permitted voltage, current, and frequency tolerances at connection point, including voltage flicker and fluctuations, harmonic distortion (including existing grid harmonics and harmonic emission from device), power factor, and voltage unbalance**

See Power (power quality)

**Predicted and measured data relating to component level reliability metrics**

Maintenance metrics are defined as:

|                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------|
| Maintenance target: Meantime Between Failures – 25 months<br>Max Maintenance Downtime – 3 days<br>Planned Maintenance – Every 24 months |
|-----------------------------------------------------------------------------------------------------------------------------------------|

All components within the turbine are designed to comply with this target.

Measured data unavailable until testing is completed