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Facility upgrades and large maintenance tasks needed at the NASA Glenn 10x10 Supersonic Wind Tunnel requires significant planning to make sure implementation proceeds in an efficiently and cost effective manner. Advanced planning to secure the funding, complete design efforts and schedule the installation needs to be thought out years in advance to avoid interference with wind tunnel testing.

This presentation describes five facility tasks planned for implementation over the next few years. The main focus of the presentation highlights the efforts on possible replacement of the diesel generator and the rationale behind the effort.

Facility Upgrade/Replacement Tasks ('Planned') at the NASA Glenn Research Center 10x10 Supersonic Wind Tunnel

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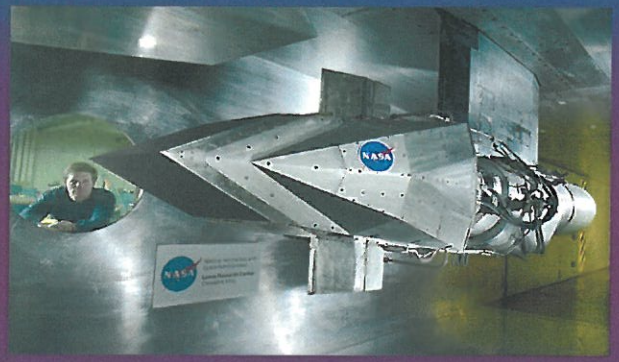
Cleveland, Ohio USA

NASA Glenn Research Center
Cleveland, Ohio

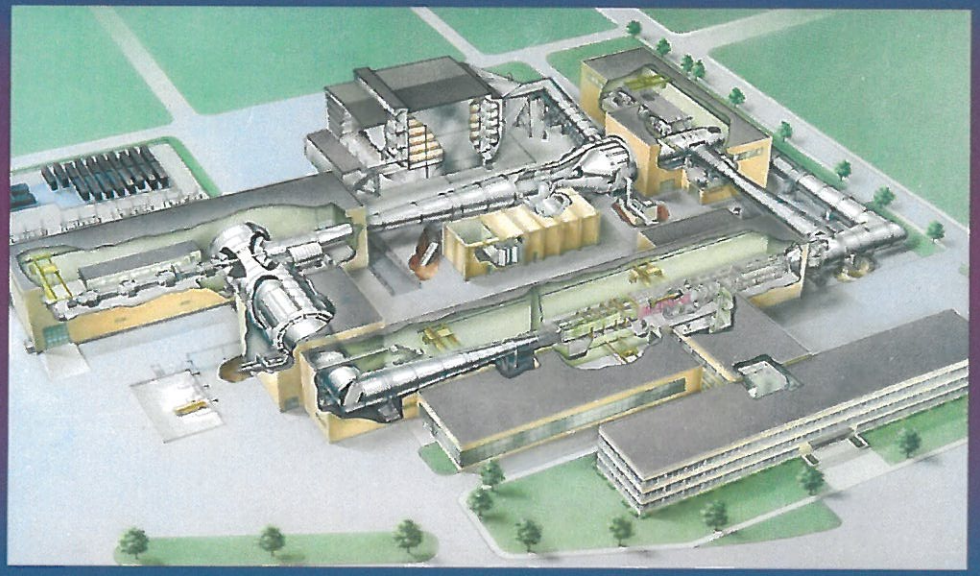
Glenn Research Center
Cleveland, Ohio

10x10ft. Supersonic Wind Tunnel

Test Section
10ft.x10ft.x40ft. long



Supersonic and Subsonic test modes
Aerodynamic–Closed loop
Propulsion–Open loop



Mach No.: 2.0 to 3.5
and 0 to 0.4 (240 knots)
Altitude: 50,000 to 150,000 ft.
Temperature: 60° to 680°F
Fuels: Liquid JP, hydrogen and oxygen
Continuous Operation: 250,000 hp drive motors
Remotely accessible real-time data display

CD-98-77058

10x10 SWT Facility Layout

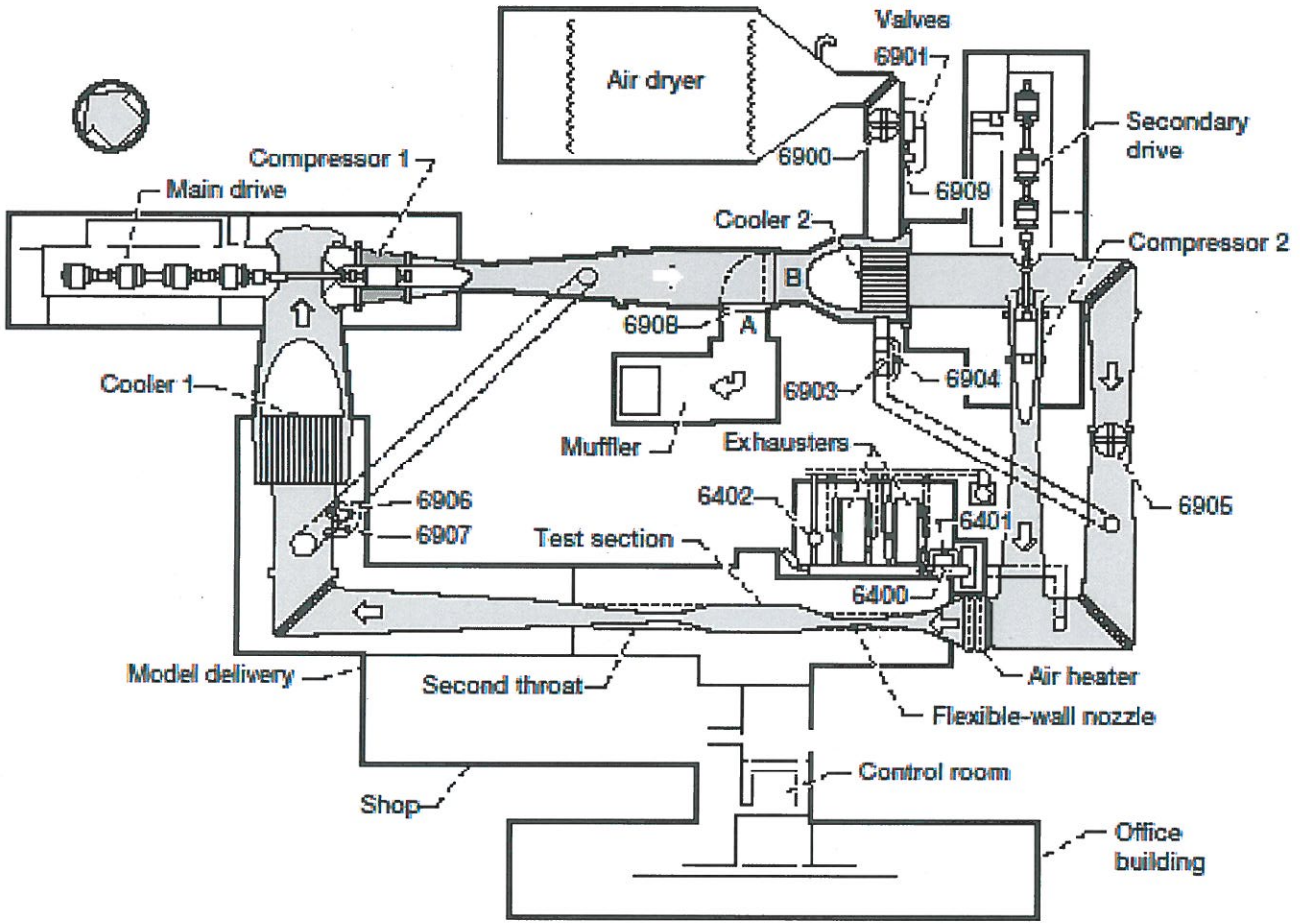


Figure 1.—10- by 10-Foot Supersonic Wind Tunnel (10×10 SWT).

Top 5 Projects 'Planned' over the next few years

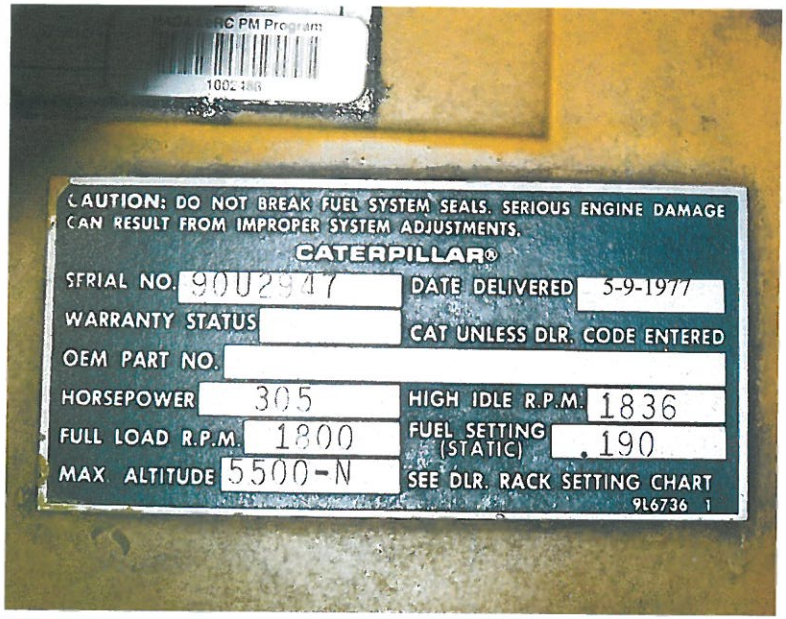
1. Facility control system replacement
2. Facility data system replacement
3. Air Dryer building - rehab
4. Expansion Joint No.2 - replacement

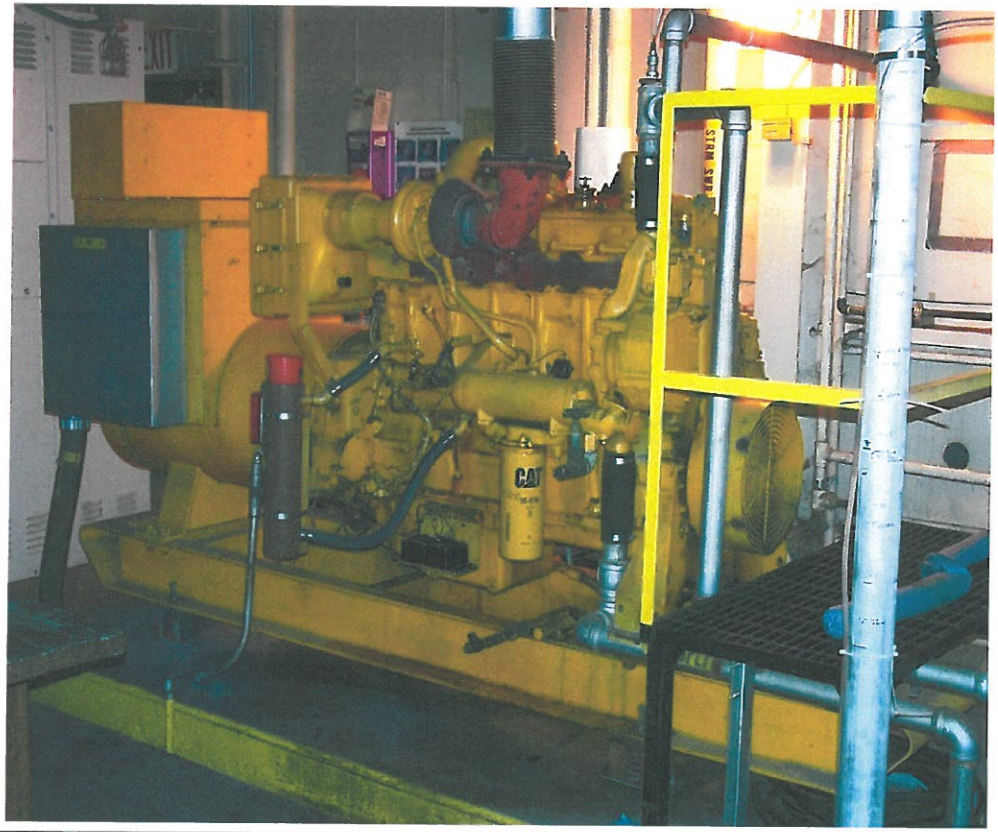
5. Diesel Generator – replacement

Diesel Generator – Replacement

Diesel Generator – current model

- Caterpillar model: Model 3406
- 1977 vintage
- 305 Hp
- 210 kw

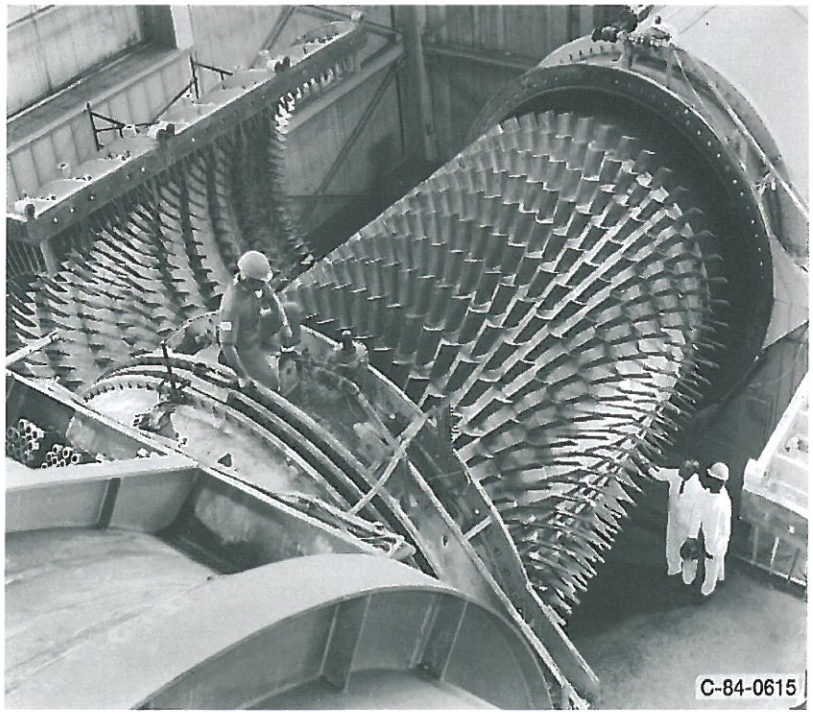




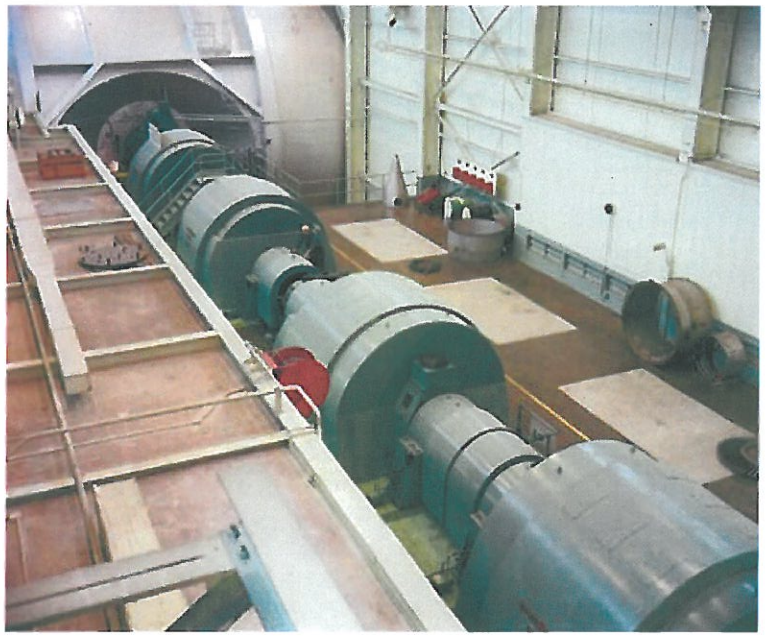
Diesel Generator – replacement

Diesel Generator – what is it used for?

- It provides the primary electric power to the oil supply equipment for all motor and compressor driveline bearings. Grid is backup power source.



Compressors



Main/Secondary Drive Motors

Diesel Generator – Replacement

Diesel Generator – current system lubrication needs

- Main Drive (D1):
  - 13 bearings total
    - (4) Compressor (2 radial, 1 thrust, 1 stud shaft)
    - (9) Four 40k hp motors (2 radial per motor, 1 thrust)
      Disconnect Coupling

- Secondary Drive (D2):
  - 11 bearings total
    - (4) Compressor (2 radial, 1 thrust, 1 stud shaft)
    - (7) Three 40k hp motors (2 radial per motor, 1 thrust)
      Disconnect Coupling

- Lube System
  - Four ~ 15 hp pumps per Drive (8 pumps - total of 120 hp)
  - Total of 985 GPM combined (D1 & D2)

Diesel Generator – Replacement

Diesel Generator – current model

- Typical hours of operation / fuel burn per:
  - Test night: 10 hours / 6 – 9 gallons per hour (fuel usage depends whether using 1 or 2 drives)
  - Yearly Average: ~ 300hrs (based on 10,110 total hours in 35 years)
  - 2011: 366 hrs
  - 2012: 160 hrs
  - 2013: TBD

Diesel Generator – Replacement

Diesel Generator – operating adequately, why replace it?

- Lack of spare parts?
  - ❖ Replacement voltage regulator had to be retrofitted to work with current generator
  - ✓ Adequate spares available for diesel motor itself
  - ✓ Replace the generator portion of the unit if it becomes unserviceable

- Reliability concerns?
  - ❖ Fuel manifold failure
  - ❖ Unit fails to shutdown on occasion (dieseling)
  - ✓ An old machine, but considered middle aged by industry standards
  - ✓ Local service vendor is very responsive

Diesel Generator – Replacement

Diesel Generator – operating adequately, why replace it?

- Environmental Issues !
  - Noise (105db)
    - hearing protection required for walk-arounds
  - Underground storage tank –double walled (1000 Gal)
    - Yearly inspection costs
    - Potential for leaks / cleanup
  - Exhaust emission compliance by May-2013
    - New specifications for 2010 now cover this class of equipment >300hp, > 120 hours of operation per year, ppm limits, etc...
    - New specifications require emissions testing

- Emission Standards -
Existing RICE Located at Area Sources
(RICE - Reciprocating Internal Combustion Engines)

HP	Engine Subcategory					
	Non-emergency					Emergency or Black start
	Compression Ignition (CI)	SI 2SLB	SI 4SLB	SI 4SRB	SI LFG/DG	
≤300	Mgmt practice standards					Mgmt practice standards
300-500	49 ppm CO or 70% CO reduction*					
>500	23 ppm CO or 70% CO reduction*		47 ppm CO or 93% CO reduction**	2.7 ppm CH_2O or 76% CH_2O reduction**		

We want to be in this category.
Mgmt practice standards = normal maintenance practices. No emissions testing required.

At 305 hp, we currently need to meet these emissions standards.

Limits in yellow are expected to require emissions control retrofit

Compliance Requirements

Engine Subcategory	Compliance Requirements
•Existing non-emergency CI ≥100 HP at major source •Existing non-emergency SI 100-500 HP at major source •Existing non-emergency CI >300 HP at area source •Existing non-emergency SI >500 HP at area source that are 4SLB or 4SRB and are used >24 hours/year	•Initial emission performance test •Subsequent performance testing every 8,760 hours of operation or 3 years for engines >500 HP (5 years if limited use) •Operating limitations - catalyst pressure drop and inlet temperature for engines >500 HP •Notifications to EPA with each test •Semiannual compliance reports (annual if limited use) * hours of operation * maintenance records * fuel use Existing non-emergency CI >300 HP: •Ultra low sulfur diesel (except rural Alaska) •Crankcase emission control requirements

Diesel Generator – replacement

Diesel Generator – Compliance options

Compliance by Modification

- De-rate hp of existing generator to <300 hp
- Retrofit existing generator with equipment from Caterpillar

Compliance by Replacement

- New generator that is rated < 300 hp

Compliance by New Operating Procedures

- Limit hours of operation per year to <120 hours
- Make power grid primary source of lube pump power, backup (emergency) options:
  - diesel generator
  - battery bank
  - gravity feed oil reservoir

Diesel Generator – replacement

Diesel Generator – Compliance by Modification

- De-rate hp of existing generator - $600.
  - mfg can detune generator to limit output to < 300hp
  - provide new name plate with new operating specs
  - √ √ can avoid emissions testing completely
  - ❖ still carries reliability concerns & environmental issues
  - ❖ this option may not be allowed by EPA (will find out in a few months)

- Retrofit existing generator with equipment from Caterpillar, est $20k
  - ❖ cost of emissions testing before and after retrofit, est $20k total
  - √ will meet emissions specs,
  - ❖ still requires emissions testing every 3 years, $10k - $20k
  - ❖ still carries reliability concerns and environmental issues

Diesel Generator – replacement

Diesel Generator – Compliance by Replacement

- New diesel generator (<300 hp) - $200k
  - √ will meet environmental specs
  - √ < 300 hp falls into "Mgmt practice standards" category
  - √ avoids emissions testing

- New natural gas generator (<300 hp) - $350k
  - √ will meet environmental specs
  - √ <300 hp falls into "Mgmt practice standards" category
  - √ avoids emissions testing
  - ❖ may require removal of underground tank/cleanup, $
  - ❖ run new gas line to unit, $

Diesel Generator - replacement

Diesel Generator – Compliance by New Operating Procedures

- Limit hours of operation per year to <120 hours
  - ❖ Cannot be done consistently based on average yearly use
  - ❖ Would have to stop testing once the hour limit is reached

- Make power grid primary source of lube pump power, backup (emergency) options:
  - diesel generator
    - ❖ must rely on diesel to start when needed
  - battery bank *
    - ❖ safety issues and costs with batteries
    - ❖ long term maintenance issues and costs
  - gravity feed oil reservoirs *
    - ❖ cost for new installation and maintenance issues

Diesel Generator - replacement

Diesel Generator – Compliance by New Operating Procedures

- Make power grid primary source of lube pump power, backup emergency options:
  - diesel generator
  - battery bank*
  - gravity feed oil reservoirs *

* Grid failure or tripped breaker has potential for major damage to facility
  - ❖ dynamic breaking will not be available if gird fails
  - ❖ will take 1 hour for compressor drive to coast to a stop

Diesel Generator – replacement

Diesel Generator – Compliance Preference

Compliance by Modification

- De-rate hp of existing generator to <300 hp
- Retrofit existing generator with equipment from Caterpillar

Compliance by Replacement

- New generator that is rated < 300 hp

Compliance by New Operating Procedures

- ~~Limit hours of operation per year to <120 hours~~
- ~~Make power grid primary source of lube pump power, backup options:~~
  - ~~diesel generator~~
  - ~~battery bank~~
  - ~~gravity feed oil reservoir~~

Diesel Generator – replacement

Diesel Generator – Go Forward Plans

Compliance by Modification

- De-rate Hp of existing generator to <300 hp

➢ Waiting on response from Ohio EPA to GRC's request to de-rate and re-label the diesel generator for operations < 300 hp. (Don't expect this to be successful)

Compliance by Replacement

- New generator that is rated < 300 hp

➢ This upcoming year we will fund the full design of a replacement generator, with the intent of purchase and replacement the following year.
  - This may allow us to be granted an extension of meeting the May-2013 EPA compliance deadline and avoid the cost of emissions testing.
  - Money is better spent on new compliant equipment than paying for retrofitting and testing of existing units.

Diesel Generator – replacement

What if we're non-compliant by May 2013?

What are the consequences if we do nothing?

- Removal of operating permit
- Not legal to operate equipment /tunnel

What are the consequences if we try to operate after this date?

- Monetary fines of up to $25k per day
- Criminal action – jail time

What are interim options?

- Have full mitigation plan on how we intend to become compliant.
- Bring in portable generator, already emissions compliant, for temporary use until compliant unit is operational.

Thank you for you attention

Diesel Generator - replacement

Diesel Generator – Backup Information

- We feel the most safe and reliable option for powering system lube pumps is keeping the diesel generator as the primary power source and the grid as backup: the reason?

  1: If the grid fails, the diesel generator continues to operate normally until the equipment coasts down to a stop.

  2: If the diesel generator fails, the grid will provide the backup power to the lube system as the facility is brought down to a normal stop.

  It would require a simultaneous – double failure for damage to occur to the facility with the present operating configuration .
  This is Extremely Unlikely

Diesel Generator – replacement

Cost of Compliance

Contract Labor categories for typical emission test:

Engr/Scientist III/*Site Supervisor II/*Sr. Field Env Scientist I
Sr. Consultant I
Engr/Scientist IV/*Site Supervisor III/*Sr. Field Env Scientist II
Materials & Subcontracts (M&S)
Add: Overhead/G&A Expense on M&S
Subtotal – M&S Costs
Add: Fee on M&S

Additional costs:	Extra operators,	Running in a non standard configuration
	Safety Permit items	Health and Safety Plan
	Installing Railing	Installing test ports
	Coordinating access	GRC staff for oversight

1 Facility Control System overview

History and rationale for upgrade

- The WDPF control system was installed in 1990 and was upgraded to Ovation in 2002.

- Emerson will discontinue support for the Q-Line I/O cards in 2018. Control system PC's are obsolete and spare parts for them are difficult to find.

2 Data System overview

Rationale for upgrade

- Current Escort steady state data systems have components that are over 30 years old.
- Replacement parts and/or system components are no longer being made or supported by manufacturers.
- Software support for the computer systems will end in 2013

3 Air Dryer Building – Refurbishment overview

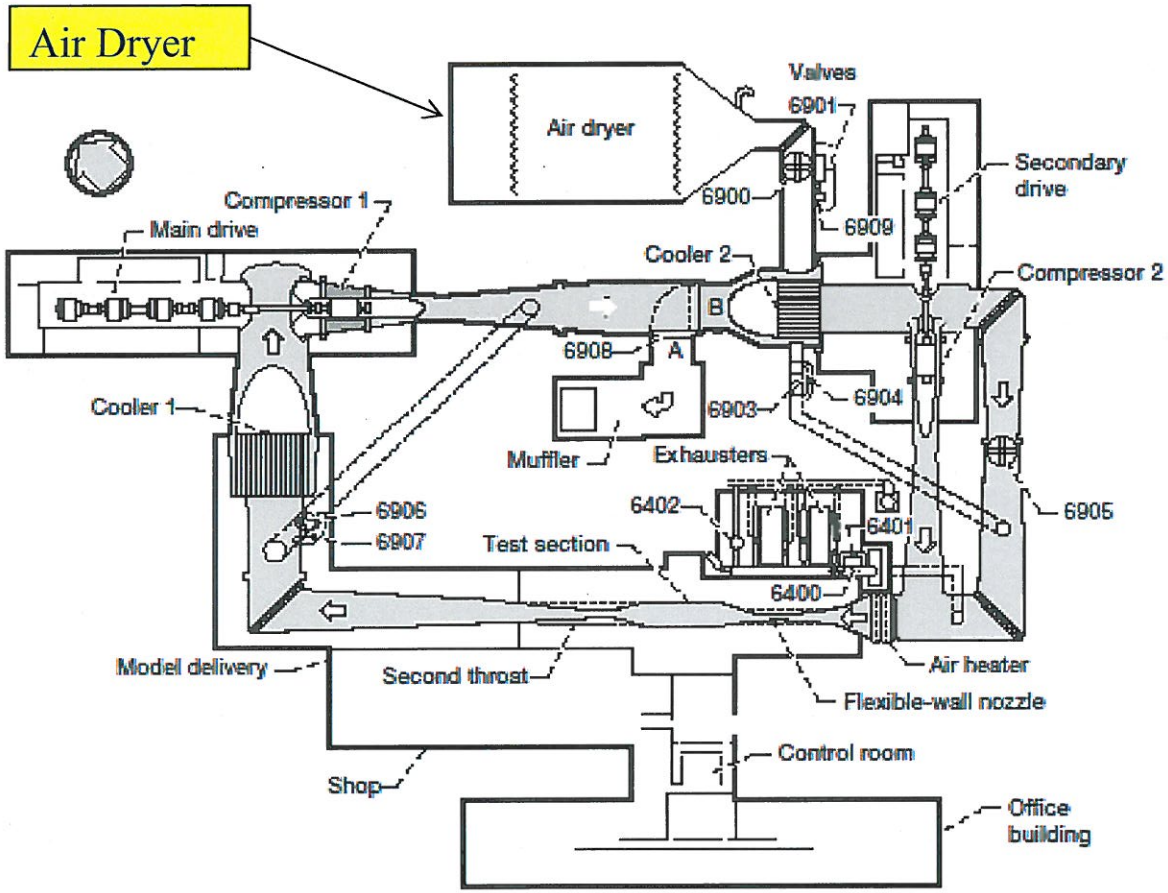


Figure 1.—10- by 10-Foot Supersonic Wind Tunnel (10×10 SWT).

3 Air Dryer Building – Refurbishment overview

Dryer Building – Air Exit

Dyrer Building - Air Intake

3 Air Dryer Building – Refurbishment overview

Back Side View

Refurbishment Areas

- Building expansion joints in need of replacement to achieve maximum operational efficiency
- Building shell in need of panel replacement – rusted through areas
- Building shell in need of corrosion protection – prevent further rusting

4 Expansion Joint No. 2 – Replacement overview

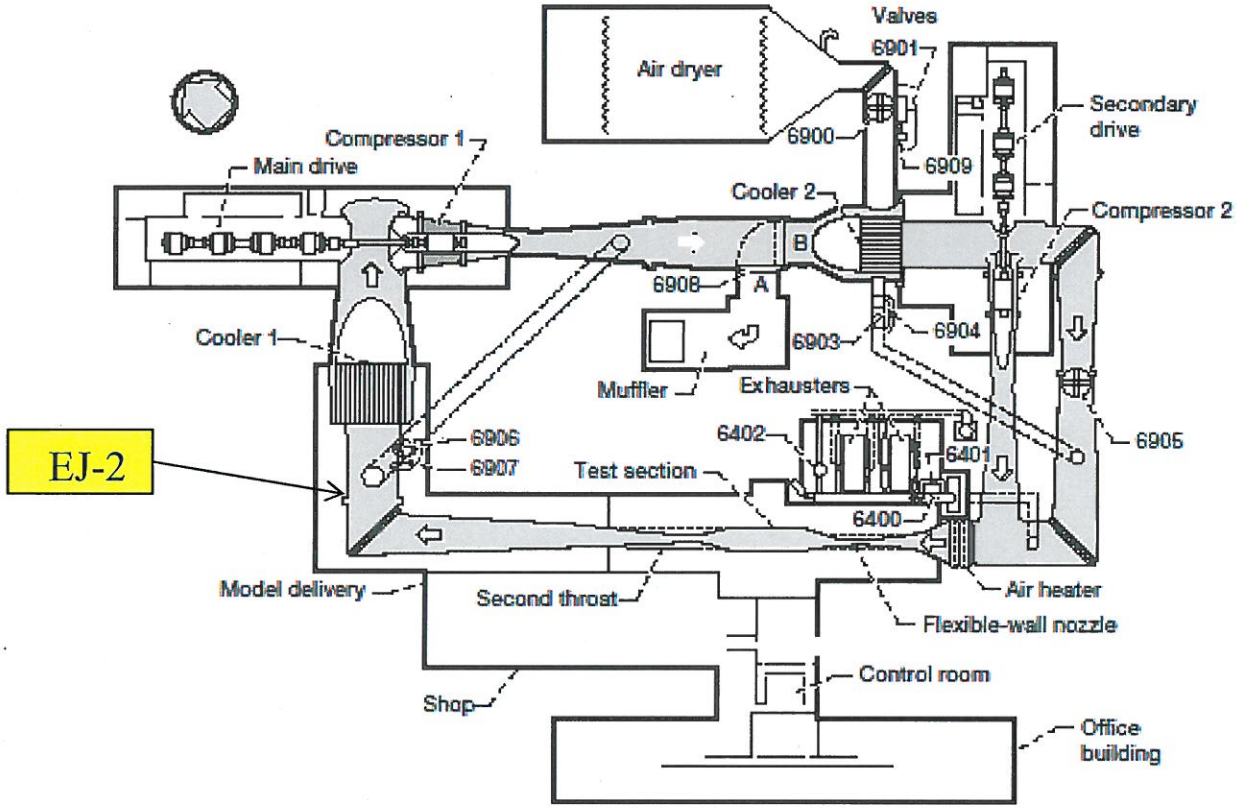
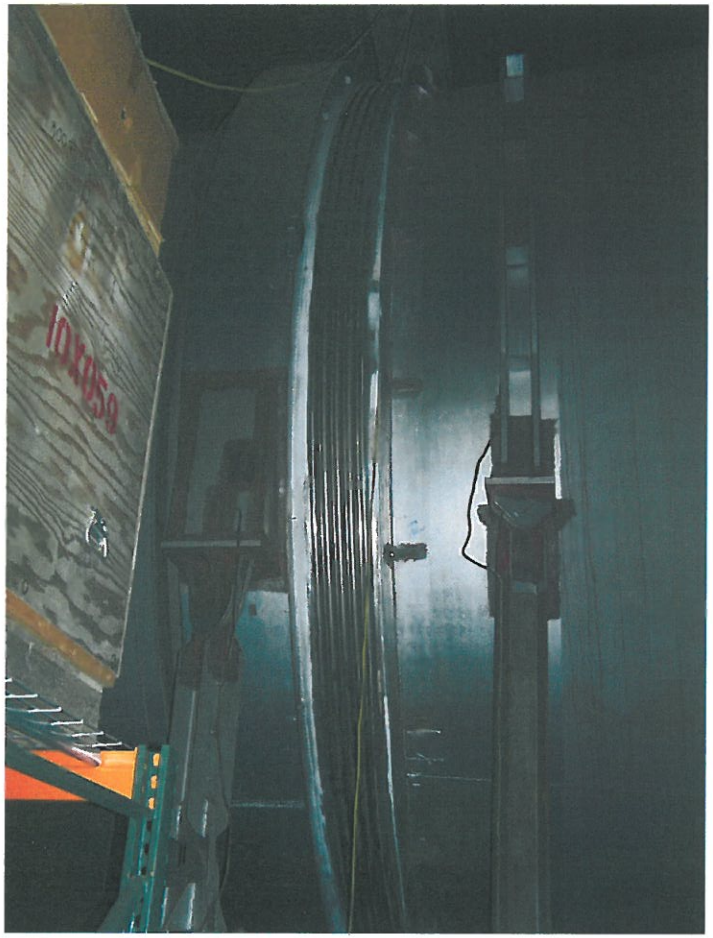


Figure 1.—10- by 10-Foot Supersonic Wind Tunnel (10×10 SWT).

4 Expansion Joint No. 2 – Replacement overview



- Diameter 26 ft
  Material: 321ss
  No. of convolutions: 5

- Crack along and across convolutions

Top 5 Projects 'Planned' over the next few years

Current Status

1. Facility control system replacement
   * Seeking funding for implementation in 2013-2014

2. Facility data system replacement
   * Seeking funding for implementation in 2013-2014

3. Air Dryer building - rehab
   * Roof leak being worked, seeking funding for remainder of work in 2013-2014

4. Expansion Joint No.2 - replacement
   * Seeking design and cost estimates for full replacement.
   * Seeking funding for implementation in 2014 - 2015