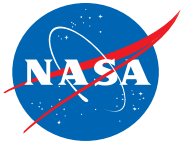

Data Logging Transducer for Pressure Vessels

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Machinery Failure Prevention Technology (MFPT)
May 13-17, 2013 Cleveland, Ohio

p/T Sensing/Data Recorder Pilot

GOAL: Provide pilot demonstration of capturing actual vessel p/T data history to enhance accuracy of “useful life” analysis over vessel’s lifetime

APPROACH:

- Select intrinsically safe, rugged pressure and temperature data logger
- Demonstrate its application in two environments
  - SSC: E-1, LN2 System, 100 psig max
  - GRC/PBS: Facility GN2 vessel, 2800 psig max
- Monitor pressure and temperature at user-programmable reading intervals
- Assess user-friendliness features of data display and analysis
- Evaluate suitability for widespread application at RPT sites

EXPECTED PAYOFF: Vessel p/T duty cycle history will be recorded for use in more accurate stress/fatigue lifecycle calculations instead of estimation, with attendant conservatism and margins in useful life projections

Glenn Research Center Status

INSTALLATION

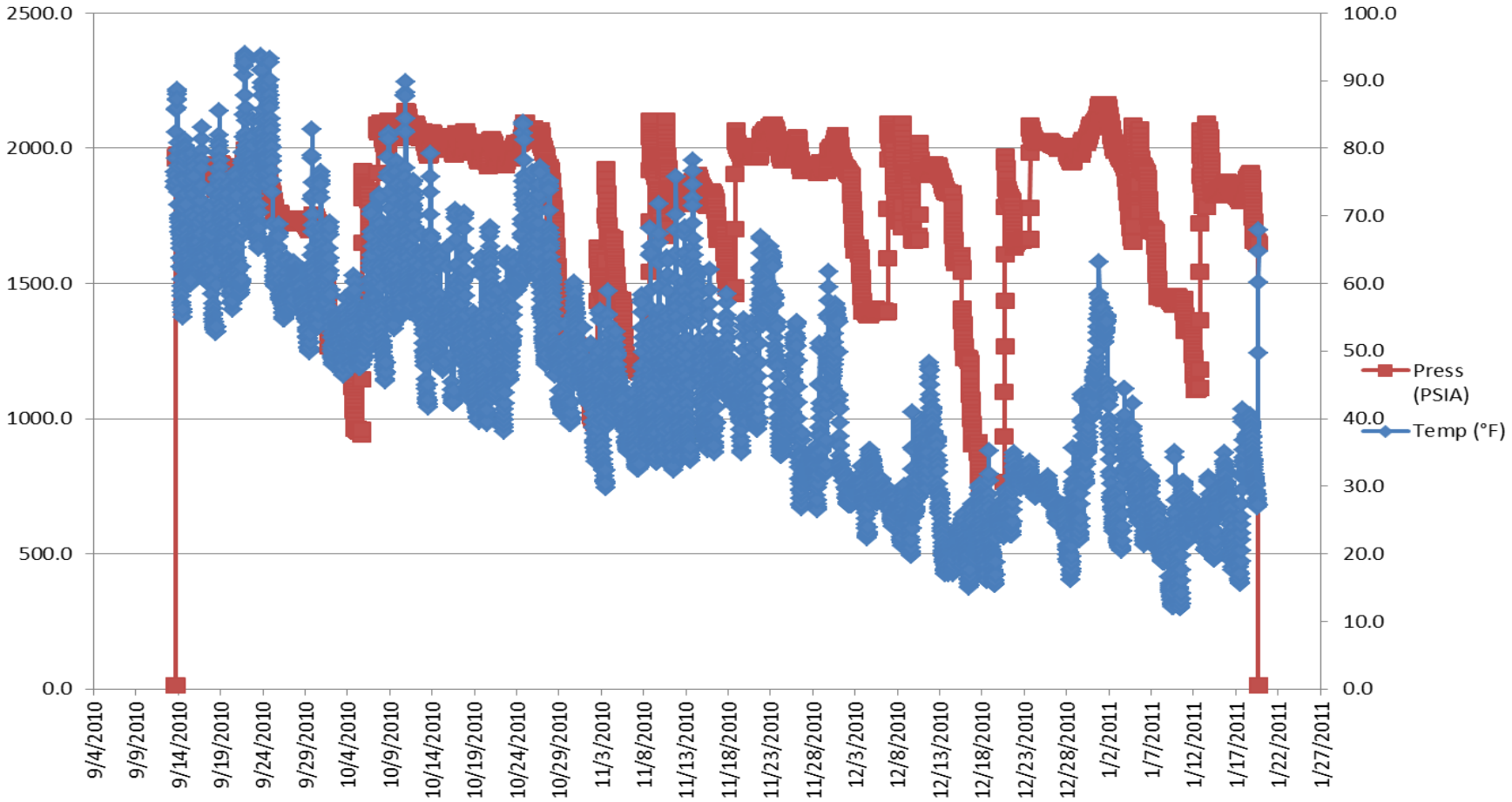
- High range transducer (0 – 5000 psig) was received, initiated, and installed on high pressure gaseous nitrogen vessel N-6-S
- Vessel operating range 1500 – 2200 psig
- Moderate continental climate with summer highs reaching into the lower 90's °F and winter lows dipping into the lower teens; winter extremes of -20°F occur on an average of once a decade
- Transducer was plumbed directly into the vessel pressure sense line in parallel with the primary pressure display gauge and was mounted on same indicator panel as gauge

Glenn Research Center Status

RESULTS

- Device was set to collect data at the default rate of once every 30-minutes (48 points per day)
- Transducer began service directly monitoring vessel gaseous nitrogen pressure in September, 2010; an initial data download was successfully acquired in January, 2011
- Transducer remained in service for two more years until January 2013
- Download of the data acquired at that time indicated that transducer memory had reached full capacity in August 2011, and that no subsequent data points were recorded

Glenn Research Center Status



4-month data set from Sept 2010 to Jan 2011

Glenn Research Center Status

PRO's

- The initial battery lasted the entire two year period, which is twice the advertised limit
- Over its two year trial period the device easily tolerated climate extremes (rain, snow, and sleet) without any special protection

CON's

- Due to unfamiliarity with the device, technicians did not know to reset the buffer
- There was no visual indication that the device was at full capacity; test trial was terminated at this time and the transducer was retired from the trial as well

Stennis Space Center Status

SSC Transducer Installation on LN2 Dewar

INSTALLATION

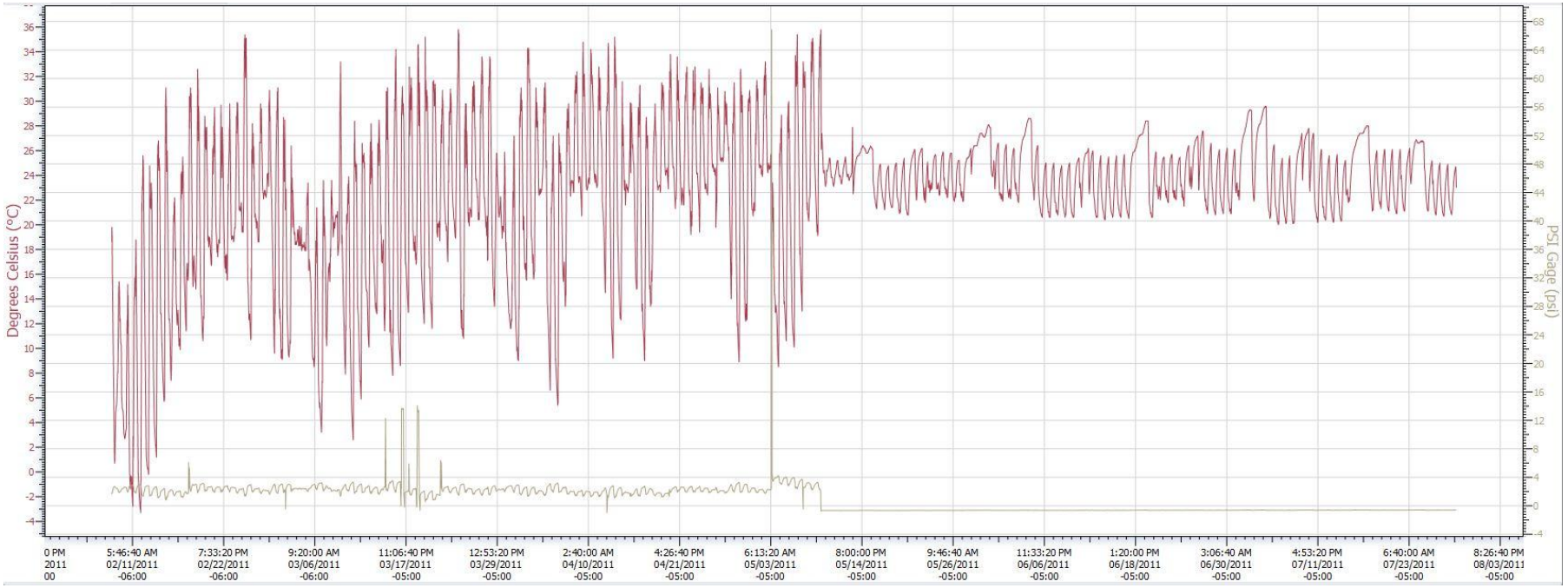
- Low range transducer (0 – 100 psig) was received, initiated, and installed on liquid nitrogen vessel
- Vessel operating pressure range of 0 – 15 psig
- Southern climate with summer highs reaching into the lower 100°F and winter lows dipping into the lower 30°F
- Transducer was plumbed directly into the vessel pressure sense line in parallel with PT-10A42-LN and was mounted on the same indicator panel

Stennis Space Center Status

RESULTS

- Device set to collect data every 15-minutes (96 points per day)
- Transducer began monitoring vessel pressure in December, 2010
- Initial data download was successfully acquired in January, 2011
- Initial data integrity was suspect – pressure and temperature cyclic trend was inverse of expected
- Review of vessel prints revealed transducer was measuring vessel low side
- Transducer memory cleared and unit reinitiated in February 2011
- Device remained in service until October 2011, yet had ceased functioning properly by May 2011
- Spikes on pressure graph corresponds with days of vessel activities (LN transfer and offloading)

Stennis Space Center Status



Information collected by data logging transducer at SSC site from Feb 2011 to Aug 2011. Pressure data is shown in grey and temperature data is shown in red.

Stennis Space Center Status

PRO's

- The initial battery also lasted as advertised
- Over its trial period the device easily tolerated climate extremes without any special protection

CON's

- There was no visual indication that the device had failed; test trial was terminated in October 2011 and the transducer was retired from the trial as well

Conclusion

- Transducer performed as advertised
- Purchase price with accessories can exceed $1000 per unit (CY2010) which makes them uneconomical for widespread application to smaller vessels
- Limited battery life and lack of visual health/status indicators could limit critical applications
- The devices are not readily calibrated and are unsuitable for high precision test data collection

Recommendation

For future application and study of data logging transducers:

- Application should involve vessels in the type of service where fatigue is a credible damage mechanism and where extending fatigue life can produce tangible savings
- Applications must involve service commodities that are compatible with the device; cryogenic fluids, gaseous hydrogen, or highly reactive commodities may not be suitable for these transducers
- For any application, a formal monitoring program should be established and personnel trained in use and operation of the transducers (these are not set and forget devices - they must be regularly checked and maintained)

Recommendation

- Seek devices with some visual health/status indicators integral to the device:
  - Having to plug into the device to determine low memory or low battery status can contribute to loss of data
  - Devices with wireless data transfer capability may be desirable in some applications
- These devices should be considered in circumstances where vessels are subject to potential out of tolerance conditions due to process control instabilities; they could provide an attractive monitoring alternative for capturing rogue excursion events