Primer on Possible Alternative Bobtail Requalification Techniques

Prepared for: NPGA T&S Committee; Sparks, NV

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February 28, 2006
Revised: April 7, 2006

Overall Goal:

Identify and review technologies that may help reduce on-going bobtail requalification costs without compromising safety.

Technologies Assessment Approach:

- Cast broad net within domestic/international LP Gas community (particular emphasis on developments in Europe and Australia).
- Look at related industries' experiences with non-destructive examination (NDE) techniques (e.g. petroleum refining, gas treatment, chemical plants, power generation, and aerospace industries).
- Provide a qualitative first-cut analysis of currently available NDE technologies.[1]

1. This is a work in progress. Input/suggestions/comments are welcome.

Hydrostatic Test – Room For Improvement:

- Stresses tank beyond normal operating pressure;
- Potential to negatively affect fuel quality (water, methanol, corrosion products);
- Costly:
  - Out of pocket expenses are ~$800/requalification, and
  - Lose use of bobtail for up to a week; and
- Venting of LP Gas is a safety and environmental concern.

Desired Properties for Alternative Requalification Technique/s:

- Non-destructive;
- External;
- Cost effective (includes equipment capital, training, and operating costs);
- Fast;
- Reliable;
- Provides a clear Go/No-Go reading;
- Straight-forward to perform; and
- Can enhance operational characteristics.

Non-Destructive Examination (NDE) – An Industry in Itself:

- Has grown over last ~20 years to fill needs of large, established industries for whom the costs for plant shut-downs are prohibitive. Such industries include:
  - Petroleum Refining;
  - Petrochemical;
  - Power Generation (fossil and nuclear); and
  - Oil and Gas Production.
- Huge financial incentive not to take these facilities off-line.
- Monitor pressure vessels and piping.
- Have learned to use NDE techniques as a tool to help ensure equipment availability, reliability, and continuous safe operation.
- Requires properly trained personnel to use appropriate technologies.

Possible Alternative Requalification Test Methods Currently Used in the LP Gas and Other Closely Related Industries Includes:

- Ultrasonic;
- Acoustic Emissions;
- Magnetic Particle;
- Liquid Penetrant;
- Radiographic; and
- Eddy Current.

Visual Inspection – The First NDE Technique:

- Point of departure for all identified alternative test methods.[2]
- Requires clean surfaces and good illumination.
- May be documented via photos.
- Because of complex bobtail geometries, visual-only examination is insufficient to verify tank integrity.

2. In Australia, bobtails are requalified thorough a visual inspection complemented by a range of approved NDE techniques that closely examine critical welds and other areas noted in the visual examination. (Australia does not require the hydrostatic test.)

Ultrasonic Examination

- How it works:
  - Typically, 2 transducers are attached to the tank (e.g. on either side of a weld);
  - One transducer sends ultrasonic signals through the tank, the other listens for the response;
  - Sensor response is reported to inspector; and
  - Transducers are moved (e.g. along weld) and process is repeated.

Ultrasonic Examination Cont.

- Possible Benefits to Ultrasonic Examination (UE):
  - External;
  - Advanced systems offer paper record to document UE results; and
  - Portable (able to bring UE instrument to bobtail).
- Possible Challenges:
  - Contact issues (may need to remove paint and/or sand surface to ensure good transducer/tank acoustic contact); and
  - May not be feasible to examine entire vessel. Typically all welds are examined, as well as areas that are targeted for further inquiry following visual examination (e.g. dents, corroded areas, etc.).

#	**Ultrasonic Examination Review[3]**	**Rating (1-5)**
1.	Non-destructive	5
2.	External	5
3.	Cost effective	4
4.	Fast	4
5.	Reliable	5
6.	Provides a clear Go/No-Go result	5
7.	Straight-forward to perform	0
8.	Improves operational characteristics	5
9.	Instrument portability	5
10.	Tank coverage	2
11.	Recognition by US Regulatory Agencies	0
	Total	**40**

3. This review is based on preliminary engineering analysis and is provided merely for discussion purposes.

Acoustic Emissions Examination (AEE)

- How it works:
  - Typically sensors are attached to the tanks, the tank is pressurized (to design pressure);
  - Sensors record the acoustic emissions from the tank.
  - Emissions profile is then reviewed and compared to earlier test results to determine if significant variation exists.
  - Go/No-Go result is reported.

AEE Cont.

- Possible Benefits to AEE[4]:
  - External;
  - Fast; and
  - Cost-effective (vs. hydrostatic test).
- Possible Challenges to AEE:
  - Raise pressure from operating pressure to a test pressure;
  - Normalizing procedure over a range of ambient temperature conditions; and
  - Moderate expertise required by inspector.

4. This technique has been successfully applied in France on a commercial scale (to requalify mounded LP Gas tanks).

#	**Acoustic Emission Examination Review**[5]	**Rating (1-5)**
1.	Non-destructive	4
2.	External	5
3.	Cost effective	5
4.	Fast	5
5.	Reliable	5
6.	Provides a clear Go/No-Go result	5
7.	Straight-forward to perform	2
8.	Improves operational characteristics	3
9.	Instrument portability	5
10.	Tank coverage	5
11.	Recognition by US Regulatory Agencies	0
	Total	**44**

5. This review is based on preliminary engineering analysis and is provided merely for discussion purposes.

Magnetic Particle Examination (MPE)

- How it works:
  - Typically, fine particles are applied to the surface [particles can be in powder form [Dry Powder Magnetic Particle Test (DPMPT) or a wet suspension in liquid (Wet Fluorescent Magnetic Particle Test (WFMPT)];
  - Two (2) prods are attached to the tank, prods are electrified and current (AC or DC) flows through the tank, this magnetizes the tank[6]; and
  - Particles respond to the magnetic flux lines; and
  - Defects in the tank are exposed via discontinuities in magnetic flux lines.

6. Reportedly, the tank may also be magnetized by a hand-held “horseshoe.”

MPE Cont.

- Possible Benefits to MPE:
  - Reported to be reliable;
  - May be documented via pictures.
- Possible Challenges to MPE:
  - Invasive (works best if conducted internally);
  - Arcing at prods may be an ignition risk;
  - Overheating or burning of the surface may be an issue;
  - Reportedly does not work well near welds;
  - Works best if magnetic flux lines are perpendicular to defect orientation;
  - Magnetic particles may become a fuel contaminant if not completely removed.
  - Possible complications due to induced tank magnetism.
  - Operator intensive.

#	**Magnetic Particle Examination Review**[7]	**Rating (1-5)**
1.	Non-destructive	5
2.	External	0
3.	Cost effective	2
4.	Fast	0
5.	Reliable	5
6.	Provides a clear Go/No-Go result	5
7.	Straight-forward to perform	3
8.	Improves operational characteristics	2
9.	Instrument portability	3
10.	Tank coverage	5
11.	Recognition by US regulatory agencies	5
	Total	**35**

7. This review is based on preliminary engineering analysis and is provided merely for discussion purposes.

Liquid Penetrant Examination (LPE)

- How it works:
  - Tank is emptied and purged;
  - Penetrant solution (fluorescent/color contrast dye) is applied to interior surface;
  - Solution is washed away (only dye that has penetrated into surface defects remains);
  - Black light (UV) illuminates prepared surface; and
  - Surface discontinuities are visible under black light.

LPE Cont.

- Possible Benefits:
  - Surface discontinuities are readily visible.
  - Test results can be documented via photos.
- Possible Challenges:
  - Internal test (tank must have a manway);
  - Discontinuities must extend to the surface.

#	**Liquid Penetrant Examination Review**[8]	**Rating (1-5)**
1.	Non-destructive	5
2.	External	0
3.	Cost effective	2
4.	Fast	0
5.	Reliable	4
6.	Provides a clear Go/No-Go result	5
7.	Straight-forward to perform	3
8.	Improves operational characteristics	2
9.	Instrument portability	5
10.	Tank coverage	5
11.	Recognition by US Regulatory Agencies	5
	Total	**36**

8. Ibid.

Radiographic Examination (RE)

- How it works:
  - Typically consists of X-Ray emitter on one side of tank wall, film/detector on the other side;
  - Instrument/film is moved around tank and procedure is repeated; and
  - Images on film are developed and inspected.

RE Cont.

- Possible RE Benefits:
  - Well established technology;
  - Documentable results; and
  - Can detect discontinuities not extending to the surface.
- Possible Challenges:
  - Internal method;
  - Expensive;
  - Low tank surface coverage;
  - Equipment is typically not mobile; and
  - Health risk (radiation exposure).

#	**Radiographic Examination Review**[9]	**Rating (1-5)**
1.	Non-destructive	5
2.	External (not necessary to go inside vessel)	0
3.	Cost effective	0
4.	Fast	0
5.	Reliable	5
6.	Provides a clear Go/No-Go result	5
7.	Straight-forward to perform	0
8.	Improves operational characteristics	0
9.	Instrument portability	2
10.	Tank coverage	2
11.	Recognition by US Regulatory Agencies	5
	Total	**24**

9. Ibid.

Eddy Current Examination (ECE)

How it works:

- Typically sensor is moved incrementally over external surface of tank;
- Magnetic field/s generated by sensor induces eddy currents in the tank; and
- Instrument monitors, records, and reports sensor output.

ECE Cont.

- Possible ECE Benefits:
  - External; and
  - Results may be documented via printed/electronic sensor outputs.
- Possible ECE Challenges:
  - Relatively new as a field test instrument;
  - Requires high level of inspector expertise;
  - May be sensitive to surface roughness;
  - Low tank coverage; and
  - Possible residual magnetic field issues (may need to de-magnetize tank before/after test).

#	**Eddy Current Examination Review**[10]	**Rating (1-5)**
1.	Non-destructive	5
2.	External (not necessary to go inside vessel)	5
3.	Cost effective	3
4.	Fast	3
5.	Reliable	5
6.	Provides a clear Go/No-Go result	5
7.	Straight-forward to perform	0
8.	Improves operational characteristics	5
9.	Instrument portability	3
10.	Tank coverage	2
11.	Recognition by US Regulatory Agencies	0
	Total	**36**

10. Ibid.

#	**Hydrostatic Test Review**[11]	**Rating (1-5)**
1.	Non-destructive	2
2.	External (not necessary to go inside vessel)	0
3.	Cost effective	2
4.	Fast	1
5.	Reliable	3
6.	Provides a clear Go/No-Go result	5
7.	Straight-forward to perform	5
8.	Improves operational characteristics	0
9.	Instrument portability	2
10.	Tank coverage	5
11.	Recognition by US Regulatory Agencies	5
	Total	**30**

11. Ibid.

NDE Techniques Comparison[12]

#	NDE Technique	Total
1.	Ultrasonic Examination	40
2.	Acoustic Emissions Examination	**44**
3.	Magnetic Particle Examination	35
4.	Liquid Penetrant Examination	36
5.	Radiographic Examination	24
6.	Eddy Current Examination	36
7.	Hydrostatic Test	30

12. Ibid.

Conclusions:

1. There is no silver bullet;
2. Several NDE techniques look promising (AEE and UE in particular) but they are not at a point where they can be readily “digested” by the US LP Gas industry; and
3. NDE is an engineered solution. It will take considerable effort to adapt it to LP Gas industry’s needs.

Note: It may turn out that a judicious blend of NDE techniques may best serve the US LP Gas industry.

Possible Next Steps?

Thank You!

Special thanks to the folks at Elgas (Australia) and TOTALGAZ (France) for their willingness to share information re: on-going work to implement NDE techniques to reduced costs and improve safety in the LP Gas industry.