Trip Report- ETM Burgos, pressure vessel mfr, SERA, pump mfr.

Derek Shuman

Lawrence Berkeley National Laboratory, Berkeley CA, USA

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1 ETM

A potential manufacturer for our pressure vessel, ETM in Burgos, Spain was visited by Igor Liubarsky, Sara Carcel, and myself, on Wednesday Nov 9, 2011 for the purpose of assessing the suitability of this manufacturer to fabricate the Next-100 pressure vessel successfully. The manufacturer has been visited prior by Sara Carcel and has seen prior versions of the present DRAFT specification and drawings. We showed the latest version of the pressure vessel which now incorporates the 12 cm copper liner, but did not discuss the latest or earlier specification, in detail.

1.1 Impressions

ETM's primary business is heat exchangers, of the tube/shell type. These are pressure vessels that have an internal tube array mounted inside a larger shell that is used to circulate a cooling medium around the tubes. There are thus two separate pressure sections that must remain isolated from each other. This type of construction requires a high degree of care in both design and fabrication to work correctly, likely more so than needed for the pressure integrity of our vessel. However it appears that their concerns are specific to this type of construction. ETM has the ability to do work to nuclear standards, and had a job for a Chinese reactor company in work - which was put on hold indefinitely since Fukishima.

Alberto Martinez is the lead engineer and met with us. He seemed like an effective leader, and very knowledgeable. We showed him our design and he saw no initial problems in the design. He suggested we look at using 321 or 347 stainless, as these grades are readily available. These are Ti and Nb stabilized grades, (to avoid chromium carbide precipitation on welding). He was also familiar with the 316Ti grade which is evidently common (though I have not yet seen it in the ASME tables). Regarding the flange material and type, he unequivocally suggested we use roll forgings. This is all he uses, and they are readily available. This allows forming an integral hub so as to place the weld off the flange. Doing so allows a smaller flange to shell weld that can be better inspected by radiography. Radiography is the preferred method and he uses it as much as possible. Less flange distortion is also the result and it appears he can then finish machine flanges then weld them to shells, there is no problem with flange distortion and no post weld heat treatment is necessary. I agree this is a preferred construction, and there is no reason to believe a roll forging will be less radiopure than a hot rolled plate. We should obtain a sample as soon as possible to check radiopurity. The problem is that one must purchase a roll

Figure 1: plant view

Figure 2: plant view showing heat exchangers in work

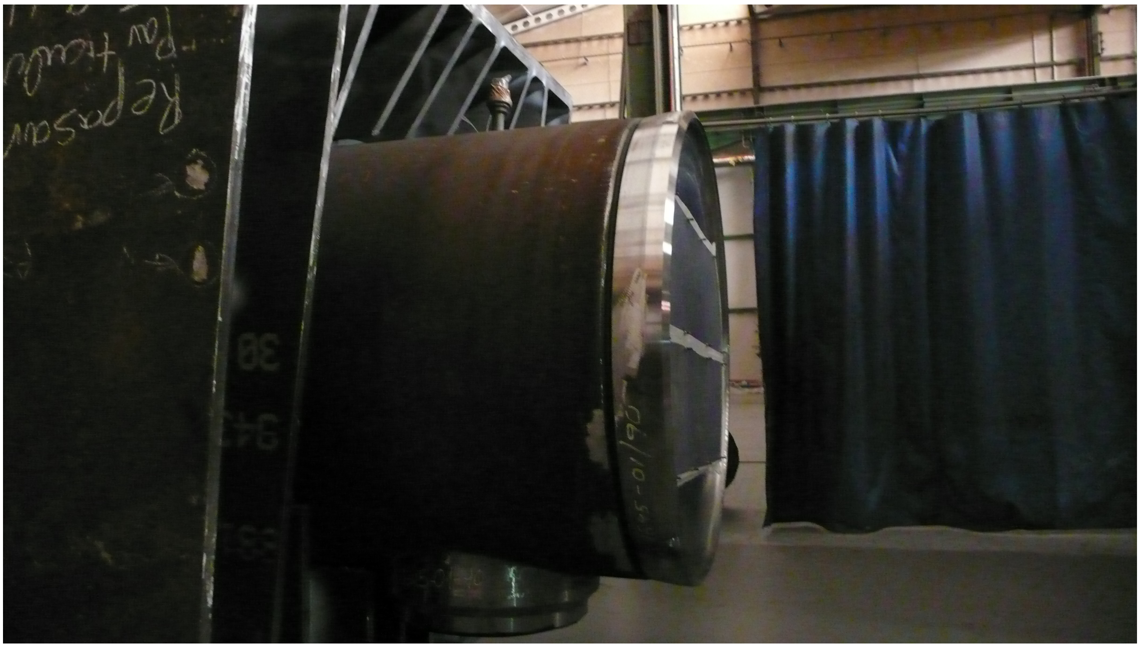

Figure 3: heat exchanger flange to vessel weld setup, nuclear job

forging prior to inspecting. We should find out if it is possible to buy the billet used for roll forging, then test a sample prior to contracting the flange rolling. Incorporating the design may be problematic though, he would like to see 50mm of straight section on the head spinning and a 30mm hub. ASME calls out for a straight section of minimum 3*thickness. He assures us that no post weld heat treatment is necessary using these design parameters. However we have not yet applied tolerances to the drawing and so this is premature. We need to see if we can incorporate this into our present design.

The flanges used in typical heat exchangers are raised face flanges and are fairly thick, though not so different from what we will have. They all appeared to be finish machined before welding; we saw no finished heat exchangers mounted on a lathe for final truing. The gaskets used are a metal/fiber sandwich, which are more tolerant of flatness variation. It is interesting to note that they specify a spiral, rather than concentric machined finish; this appears to allow bolting together in a wet condition without trapping fluid in the joint. He has a large vertical lathe, which appears to be what he would use for our vessel.

We did not ask about table speed and control is (can it be used for welding as well as machining? is it an indexing table?) Our vessel and heads will likely fit on his vertical lathe; it can take 3m dia., and so could be done. The machine is an old one, but if table bearings and tool slides are tight, a good surface finish and tight tolerances should be achievable for the O-ring grooves. We should ask further specifics here:

- What is the radial and axial table play?
- is the table indexable, so as to allow drilling an boring of flange holes, or:
- do you have a rotary indexing table you can mount.
- can you mount a side boring head for the EL inspection ports
- if not possible to weld on, how can you assure perpendicularity and parallelism of flanges if jigged and welded with a automatic tube welder?

The following tolerances (not a complete list) should be specifically addressed as to how the mfr. will achieve these:

Figure 4: heat exchanger flange (with hub) to vessel weld

Figure 5: heat exchanger tube array

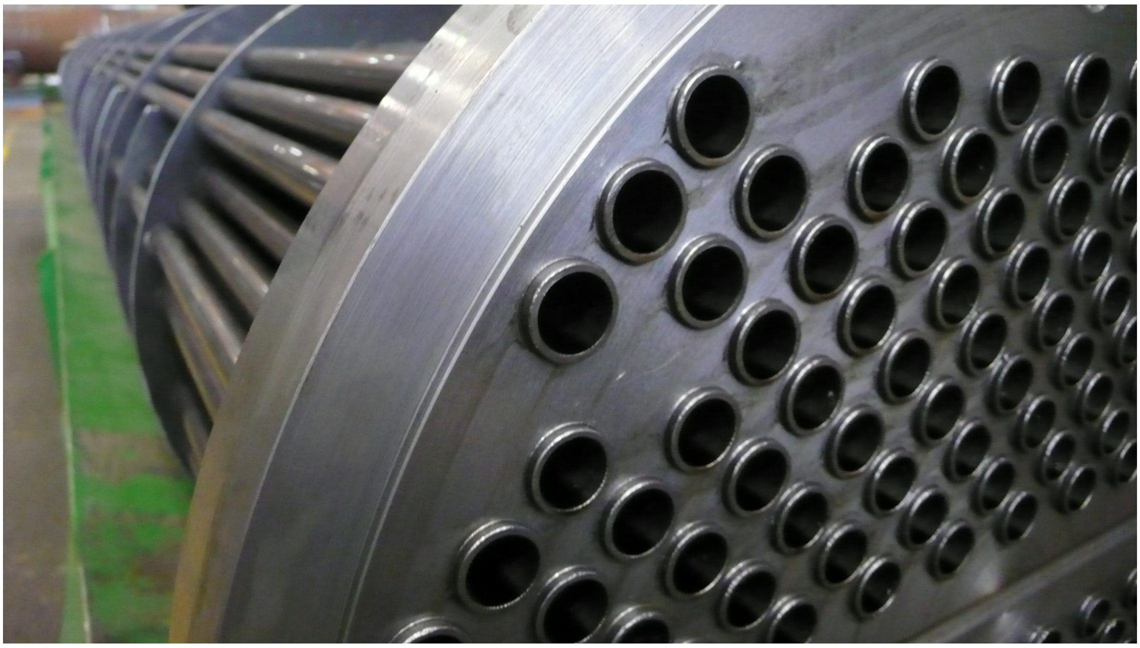

Figure 6: heat exchanger tube array2

- Flange to vessel axis perpendicularity, run out
- Flange to flange parallelism, concentricity
- Surface finish on gasket sealing surfaces
- Bolt hole matching and perpendicularity

He did say that he can do additional heat treatments, if we specify. They have an oven big enough, but only goes to 750C; he would contract out for full solution anneal.

We also talked about electropolishing, this is very expensive; they have a firm in Texas that comes out with tanks to do it. We should ask for quotes on this as an option.

Pressure testing is done using only clean deionized water- this is a nuclear standard. He has pneumatically driven high pressure water pumps that are oil free.

Weld wire is kept in a secure room, maintained at a warm temperature; probably to keep the wire dry. Any water on the wire or subtrate can create hydrogen in the weld, causing embrittlement. The wire room appeared to be well kept and organized.

He has a large ”clean room” that is essentially a separate building. It was very clean, with a shiny painted floor, it would be used for our project; it is plenty big enough. There was a small project inside with clean bagged parts that were waterjet cut for assembly. We should consider this as a fab. method, as it appears this can be done without abrasive in the jet.

The plate rolling mill appeared to be used for hot rolling plates; these are much thicker than 1 cm. I assume we can have it cleaned

Below is a torispheric head in steel after hot rolling, prepped for welding

He showed us a chart in the engineering office (several engineers working on designs) showing the minimum heat treatments necessary as a function of the total strain in forming; our head will likely need a full solution anneal, as knuckle radius is 10x the thickness. We would specify full anneal, and he said this is no problem. A company in Bilbao does the spinning.

Figure 7: vertical boring mill (lathe)

Figure 8: plate rolling mill

Figure 9: elliptical head, weld prepped

They primarily design to ASME sec VIII division 1 rules and use a commercial program called PV-LITE which contains all the rules, equations and checks of div. 1. They do not do finite element analysis (for division 2 part 5 design by analysis) but can contract it out.

He showed a typical Manufacturer's Design Report that they produce; it was a binder 5 inches thick containing material certs, design calculations, welder qualifications and procedures, inspection and test reports. It was very well organized and produced, and all the needed signatures and approval stamps at the various stages appeared to be in place.

2 SERA visit

We paid a visit to SERA pumps in Immmenhausen, Germany, on Friday the 11th of November, regarding the purchase of a metal diaphragm pump suitable for xenon circulation. We met with Ralf Held, Head Engineer. The company was well prepared for us, and Mr Held spent the better part of a day with us.

2.1 Impressions

This company is not a large company and makes both metal diaphragm compressors for various industrial processes, as well as some other types of diaphragm pumps. Mr Held is very familiar with the present IFIC pump design. They are competitors with a number of other companies; the basic patents on these types of metal diaphragm compressors being long expired. SERA is family held, and is conservative about pursuing new business opportunities. They appear to be very interested in our application.

These types of pumps seem to be the only hermetic pump capable of maintaining a positive hermetic seal between the process gas and the atmosphere and/or oil needed to operate the diaphragm. The triple diaphragm construction also allows sensing of diaphragm failure onset, as the middle diaphragm incorporates a channel that allows any leaking gas or oil to find it's way to the sense port.

Mr Held discussed our application, and as a result of our desire to have at least one year of continuous operation before replacing the diaphragms, is going to quote on a compressor having a larger head, running at a slower speed. He also suggested we go to a horizontal axis pump head, to ease diaphragm replacement; this orientation is easier to bleed air from the oil system.

The SERA diaphragm stack is different from other mfrs (PPI, PDC) in that they use a halogenated hydrocarbon oil to lubricate the middle diaphragm. This has the benefit or longer diaphragm life and the ability to pull suction pressures lower than 1 bar (some down to 200 mbar) without pulling a vacuum on the leak sense port; the oil keeps the diaphragms from separating. It may also provide superior lubrication, leading to longer diaphragm life. Other mfrs. use a brass or PTFE coated SS middle diaphragm for lubrication. No manufacturer warrants an infinite diaphragm life, even though the design stress in the material is under the fatigue limit. SERA's diaphragm material is a 301 SS, shotpeened for a residual compressible surface stress, They find more conventional stainless alloys and Hastelloy, etc. to have lifetimes as low as 20% of 301.

This is a possible disadvantage for us, in that we prefer to pull a vacuum so as to be able to recover xenon in case of a leak. The diaphragm oil vapor pressure is unknown and Mr. Held is going to send us the specification for it. The standard method of sensing diaphragm leakage is to sense a pressure rise in the leak check port. The concern with this method is that a progressing xenon side diaphragm leak must grow to a higher leak rate than the leak rate of the leak sense volume; if leak progression is slow, an undetermined, potentially significant amount of xenon might be lost before sufficient pressure

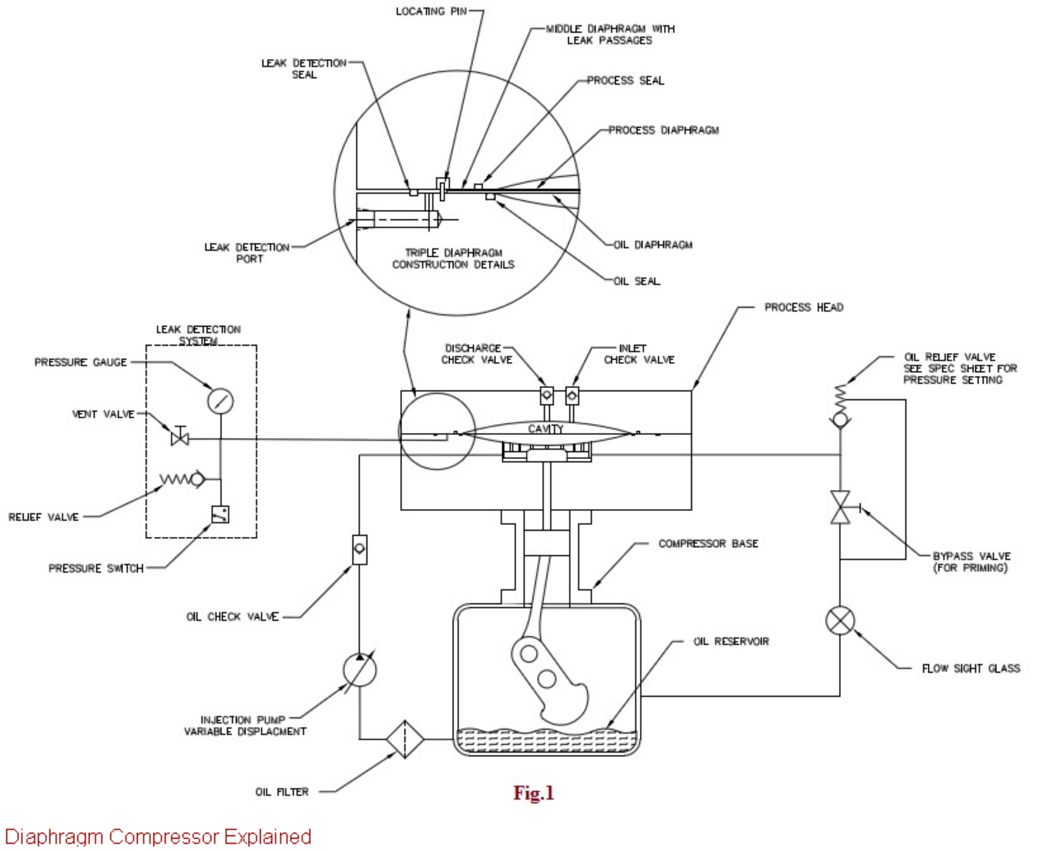

Figure 10: triple diaphragm leak sense scheme (from PDC Machine, all similar

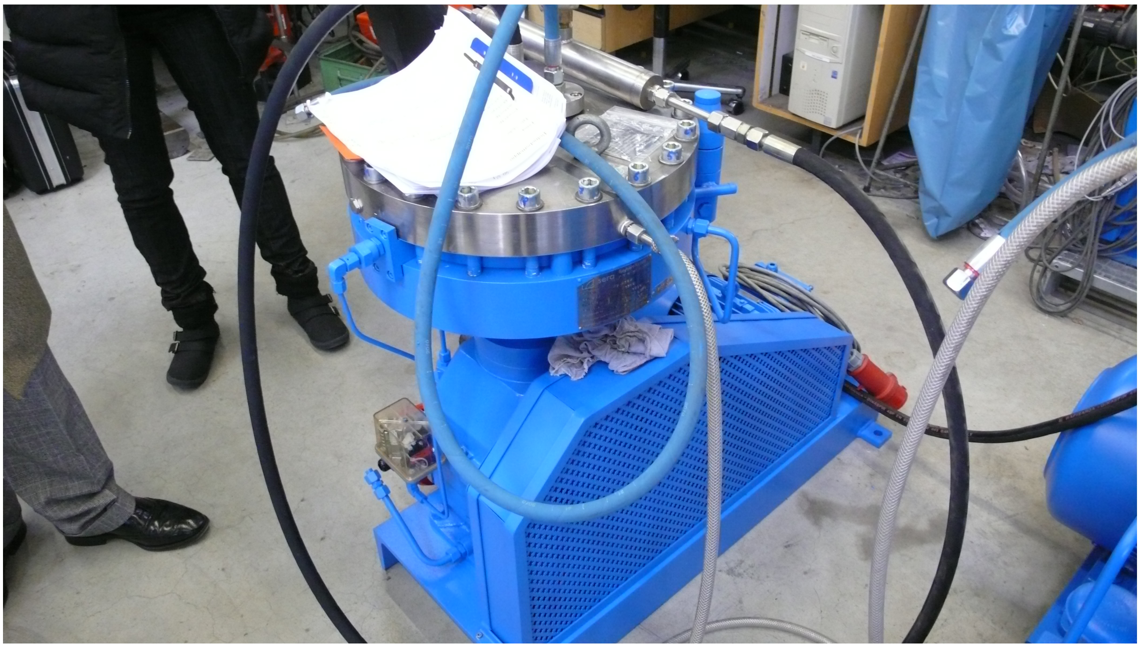

Figure 11: typical small SERA pump, older head design

Figure 12: process (gas-side) diaphragm

Figure 13: fretting at flexure point, site of failure

Figure 14: signal(middle) diaphragm

is generated to give a fault signal. Regardless of pump choice, it is going to be imperative to change diaphragms on a strict schedule. SERA does not have experience with dry coated middle diaphragms, but said they could consider this as development project.

None of the pumps designs we have seen so far provide full hermeticity in case of diaphragm leakage, as the leak sense volume and port are common for both oil and gas diaphragms; a slow oil leak and gas could develop simultaneously and progress slowly before a pressure signal was generated. This hermeticity might be accomplished by using an embossed (rather than slotted) middle diaphragm, PTFE coated, that is larger in diameter than the two outer diaphragms and is then sealed on the periphery, between the two heads, thus creating two separate leak sense volumes. This is a modification which might be easy for some pump manufacturers to make, as the head has a single split plane, however, the SERA pump has a counterbored head design which makes this more difficult. We have not proposed this design modification to any mfrs as of yet.

Figure 15: oil side head, process head, diaphragms and oil channel plate removed, showing piston, newer design