VSR Technology Group
The cost effective alternative to heat treatment

Report on Vibratory Stress Relief

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This Report describes using the VSR Process on a fabricated 20' dia. Inlet with Dome cover Assembly, made of 304 stainless steel. This Assembly was welded to a 28' dia. vacuum furnace. The fit between the Dome and Inlet flanges, responsible for the integrity of the furnace's seal, was a major concern to ALLVAC, and VSR TECHNOLOGY's Vibratory Metal Stabilization Process was chosen to stress relieve the Assembly prior to welding it to the furnace.

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ALLVAC is a manufacturer of exotic alloys, all of which are alloyed in a vacuum furnace vessel. The VSR Process was used in the final construction of a vacuum vessel which required the addition of a 20' dia access Inlet.

The vacuum vessel, fabricated of 304 stainless steel, consisted of a 28' dia. cylinder with a dome-shaped top and bottom (see Photo 1, pg 5). The Inlet Assembly was to be welded to the side of the vacuum vessel. The Inlet and its hinged Dome cover were being fabricated as a unit (back-to-back), with the Dome flange secured to the Inlet's flange. The mating surfaces would be sealed by an O-ring between them. (See Photos 3, 4 and 5, pg 6).

A major concern about this fabrication/construction process, and the reason they needed to be fabricated "back-to-back", was the possible distortion of the mating flanges during the joining of the Inlet Assembly to the vessel. The concern was that after the components were fully fabricated, and the two mating flanges were separated (when the Dome was swung open), that distortion would ruin the quality of fit between the two components and destroy the integrity of the vacuum seal. If this problem occurred, the remedy would not only require that extensive corrective fit-up work be performed, but also the work would have to be done in stages since the Assembly could change shape over a period of months. The purpose of the VSR Treatment was to minimize the likelihood of distortion taking place when the Dome cover was opened.

The Inlet and Dome fabrication, shown in Photos 3-6, pg 6, shows a close-up of the Dome flange and the mating Inlet flange, and the temporary bridge clamps welded across the mating line.

VSR SETUP

The workpiece was lifted and placed on the four (4) Isolation Load Cushions which had been placed in a 6' square pattern with the Cushions resting on oak supports. The oak supports were used to both prevent shifting of the workpiece during Treatment (because of the curved shape of its bottom surface), and provide clearance between the Assembly and the floor. The cushions were placed far from the corners or ends of the Assembly to minimize vibration damping, and thereby allow full resonating response from the workpiece, an essential element of the VSR Process.

A Vibrator mounting flange was temporarily welded to the underside of the Dome flange (see Photo 2, pg 5). This attachment method permitted the most secure mounting of the Vibrator, so it could efficiently transfer its energy into the workpiece.

The location of the Vibrator mount (between the tallest portions of the Assembly), was chosen so as to maximize the responsiveness of the Assembly to vibration.

The VSR Process uses an Accelerometer (an electronic sensor whose output is proportional to acceleration), to measure and record the intensity of workpiece vibration. This is because acceleration is proportional to force (F=ma, Newton's 2nd Law), and VSR Technology uses relative force as the engineering unit most indicative of a workpiece's response to vibration treatment. The Accelerometer was clamped about 10' from the Vibrator, and oriented to be most sensitive to vertical deflections. Those residual stresses within the workpiece that are most likely to cause unacceptable distortion of the flange surfaces, *ie,* loss of flatness of the mating surfaces, were aligned perpendicular to the mating surface plane. Thus, the Vibrator was oriented so as to generate high levels of force in this (vertical) direction, and the Accelerometer was oriented so as to detect movement in the same vertical direction.

Based on experience, the Vibrator's unbalance was initially set at 0.9 in-lbs (15% of the Vibrator's 6.0 in-lbs capacity). The setting generated very significant levels of resonant response during a quick "calibration scan" through the Vibrator's speed range. Because, at this stage in the Treatment Process, it is only necessary to observe the pattern of the Plotter's pen to make sure it is capable of plotting the workpiece's pattern of resonance peaks, results weren't recorded.

PRE-TREATMENT SCAN

A slow scan (10 rpm / sec.) through the Vibrator's speed range was made with the XY Plotter using a green pen. This plot shows the resonance pattern of the workpiece prior to stress relief. (See the VSR Treatment Chart on pg 7).

VSR TREATMENT

The Assembly was very responsive to vibration, essentially behaving similar to a tuning fork. Seven (7) resonance peaks were detected during the Pre-Treatment Scan, which was automatically generated by the VSR-790 System's XY Plotter. The five highest peaks were then individually tuned upon (the two shortest peaks were too small to require stress relieving).

The Treatment involves tuning to and dwelling upon each significant resonance of a workpiece, using enough force to cause permanent changes to take place in the resonance pattern. These changes are either "*growth"* of the resonance peak to higher levels (moves upwards on the Recorder's Chart), or "*shifting"* of the resonance peak to lower frequency (moves to the left on the Recorder's Chart), or a combination of both. Both changes are consistent with a lowering of the rigidity of the workpiece, which is the intended consequence of effective stress relieving whether accomplished using the VSR Technology's Vibratory Metal Stabilization Process, thermal stress relief, the inadvertent effect of transport, or long-term storage (sometimes called Curing or Aging).

Each of the seven (7) resonance peaks exhibited significant shifting (primarily), but also some growth. The growth can be seen in the pattern of the "*progress dots*" made during Treatment by momentarily lowering the Plotter's pen (see VSR Treatment Chart, pg 7.) As Treatment commences, the progress dot pattern, which starts above each the resonance peak, plots a course upwards and/or to the left. When the peak stabilizes (*ie*, no additional growth or shift is taking place), lowering the pen merely adds a dot onto one previously made. The next peak can then be tuned upon.

In the early phase of Treatment there was a rapid amount of change, but within minutes the change in the resonance pattern slowed and finally stabilized. This stability of a resonance pattern goes hand-in-hand with the dimensional stability of the workpiece, *ie*, the first form of stability is an indication of the second form.

Treatment time was ≈ 10 minutes per peak, although little movement was seen during Treatment of the last two peaks. After the resonance pattern stabilized, the Plotter's green pen was replaced with a red pen, and another Auto-Scan was run. This red Post-Treatment Scan, when superimposed upon the Pre-Treatment Scan, shows the final, stable resonance pattern.

RESULTS

After Treatment, the Inlet Assembly was stitch-welded onto the vacuum vessel. Welding of the Inlet-to-vessel joint was done from the outside. The section of the vessel that blocked the Inlet was then removed by flame cutting the curved circular wall inside the weld pattern. Finally, the interior perimeter of the Inlet Assembly was welded to the vessel.

After welding was completed, the temporary bridge clamps that secured the Dome to the Inlet were removed. Feeler gauges were used to determine if the mating flange surfaces had distorted which would cause a gap that would prevent the required seal. ALLVAC was delighted to find that the VSR Process had brought the fit within 0.018" when the Dome was closed and latched to the Inlet (without vacuum), which was well within the engineering department's dimensional goal.

Bruce Klauba has a degree in Physics and a Level II Vibration Analysis Certification from the American Society of Non-Destructive Testing (ASNDT). As a pioneer in the cause and effect of Vibratory Stress Relief, Mr. Klauba was named chief inventor (*Klauba et al.*) in U.S. Patent 4,381,673, which is both an equipment and process patent describing advances in the technology. He has authored numerous articles and original research papers on the subject, which have been published in leading magazines and periodicals. Published papers include:

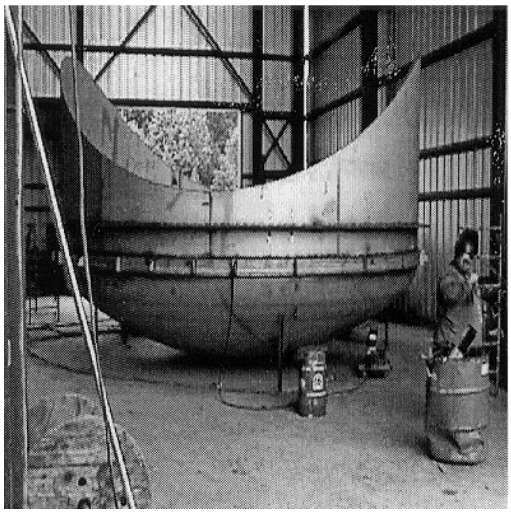
1. "Use and Understanding of Vibratory Stress Relief", *Productive Applications of Mechanical Vibration*, 1983, American Society of Mechanical Engineers.
2. "Vibratory Stress Relief: Methods used to Monitor and Document Effective Treatment, A Survey of Users, and Directions for Further Research", 2005, *Trends in Welding Research*, ASM International.

A co-author in both papers, Dr. C. Mel Adams, is a leading authority in metallurgy and co-founder of MIT's Welding Research Department. In addition, Mr. Klauba has extensive experience in designing, building, and troubleshooting Industrial and Commercial Electrical Controls with a focus on extending the performance and reliability of Electric Motors and the systems they power.

Photo 1

Photo 2

Photo 3



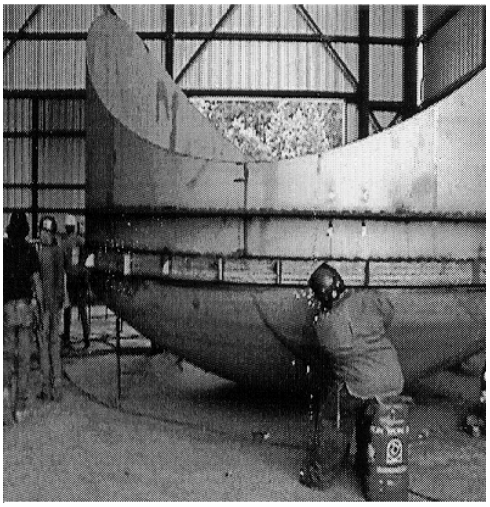
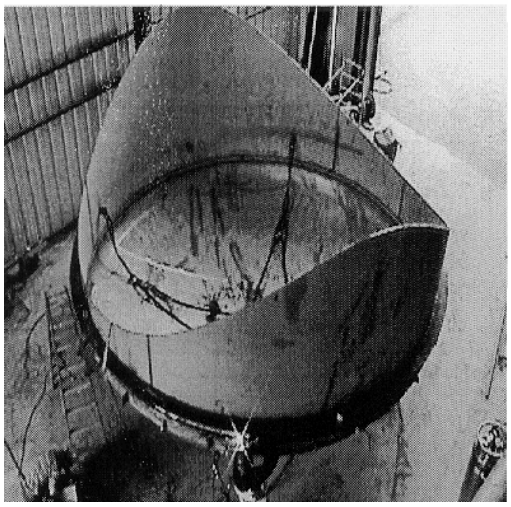


Photo 4

Photo 5



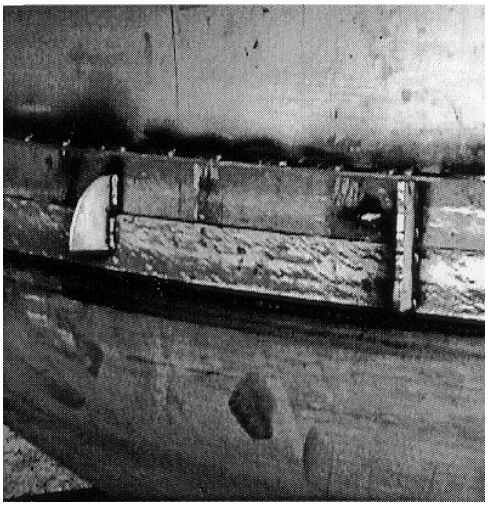


Photo 6

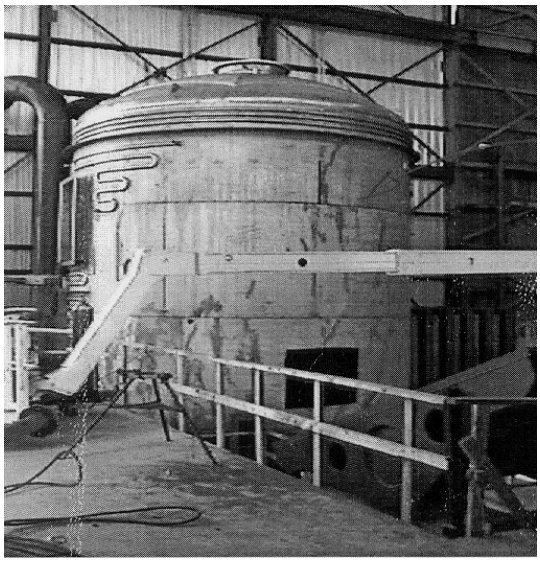


Photo 7

VSR TREATMENT
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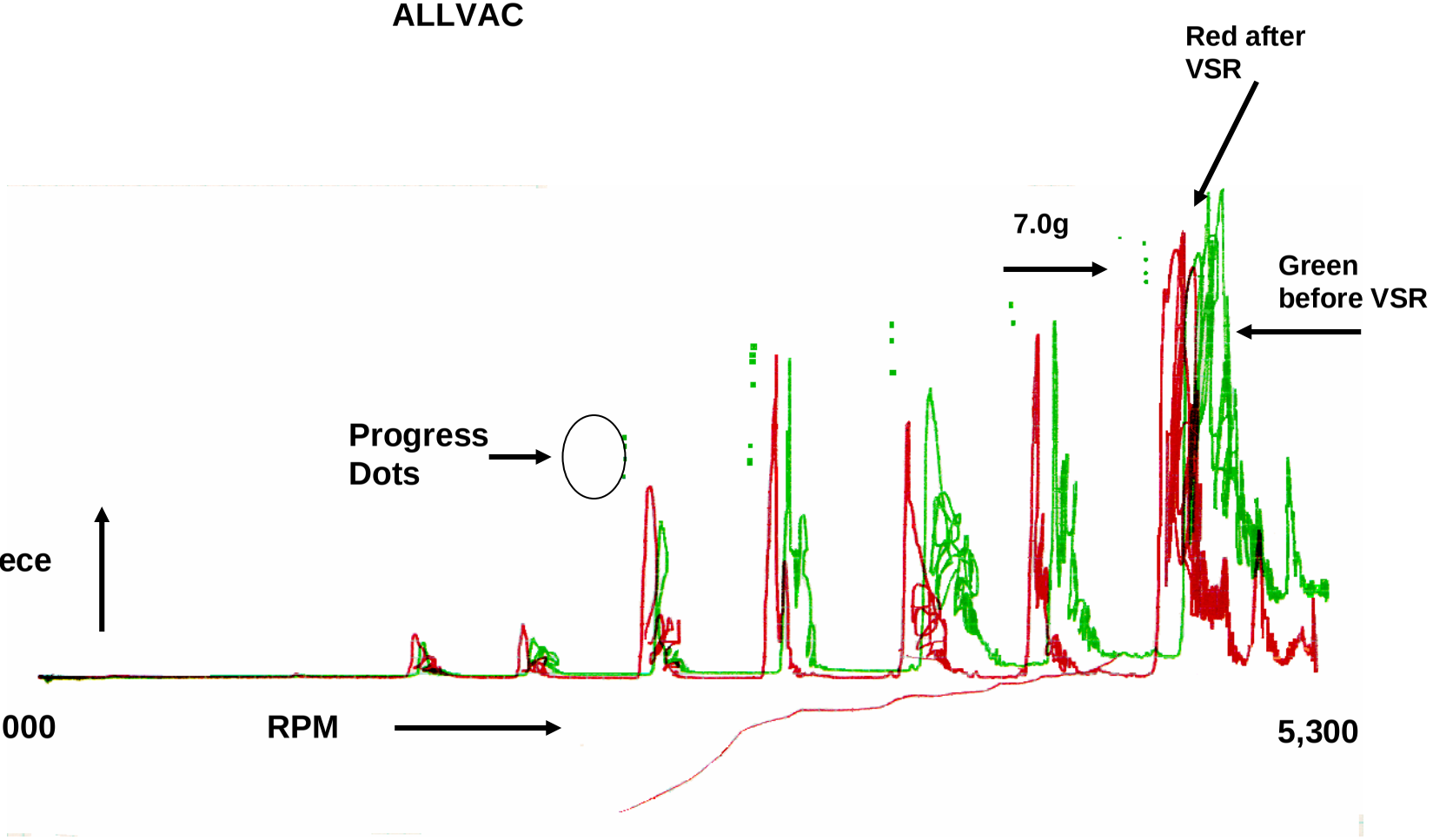

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