4 Ways to Reduce Downtime

By Thomas E. Hebel

Time is money is more than a catchy saying. It's a fact, especially if you are dealing with an emergency that involves using welding in the repair.

Your situation.
You either supervise or are part of the team that is in charge of getting critical parts back into service as fast as possible. In accomplishing this task you are expected to drop everything and work on the emergency repair until it's done. You are expected to know exactly what to do and have all the needed resources to make the repair in the fastest way possible. And you are expected to do it right the first time, every time! If anything goes wrong they make you feel like you've let the company down.

Be encouraged. There are four ways you can reduce emergency downtime.

Taking the First Step.
The first step in reducing emergency downtime is to realize that your approach to the repair may be more "traditional" than current. For example, do you still use a slide-rule or a typewriter? Yet you probably are still using the same weld repair procedure that was handed down to you years ago.

Meta-Lax technology is used during welding to make higher quality welds.
General Motors

You may not realize that technology is now available that allows you to make conventional welding go faster than ever before and at a higher quality. This technology is called META-LAX®, a development of Bonal Technologies, Inc. in Royal Oak, Michigan.

Here are four ways that you can reduce emergency downtime:
1. Weld FASTER (up to 25% faster).
2. Eliminate rework (up to 100%).
3. Perform on-site repairs.
4. Produce repairs that last longer (up to five times, that's 400% longer).

Overview of Meta-Lax.
It may be worthwhile to offer a brief overview of Meta-Lax technology now and provide more detail later about "How Meta-Lax Technology Works as Applied During Welding." See inset article. Meta-Lax is a patented sub-harmonic vibration process that can be applied "during welding" for the purpose of preventing most or all of the weld cracking. You can think of Meta-Lax as "pulsating" the entire base, not just the weld metal.

Now here are the details on how to reduce emergency downtime:

About the Author:
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1 - Reduce Downtime by Welding Faster (up to 25%)

Customer Comment:
"Meta-Lax is a real time saver. We save 2 hours out of every 8 hour shift of welding with the Meta-Lax process."
North American Ship

Situation.
Damaged components often require several hours, perhaps days, of constant welding to complete the repair.

Solution.
By using Meta-Lax technology "during welding" the welder will be able to increase his weld travel speed by up to 25% and still produce a normal quality weld. He is able to do this by increasing the normal amperage of the welding equipment by 3-15%. A higher weld quality will immediately be noticed. But if normal weld quality is fine, then the welder can increase his weld travel speed to maximize the speed of welding and adjust the other parameters (i.e. weld deposition rate and voltage) to re-establish a normal weld, not a higher quality. The goal is to maximize weld travel speed while keeping weld quality the same as normal.

Welding 25% faster while maintaining straightness and quality impressed U.S. Navy inspectors.
Western Steel & Metals

Bonus from Welding Faster
Production increases since your welders will be back "making product" sooner.

Source of Weld Cracking

When weld metal solidifies it undergoes a reduction in volume of 10-12%. This shrinkage leads to the attempt to distort the part. However the full amount of distortion that wants to occur can't because the part's own configuration resists distortion. This translates into putting more stress across the weld joint which acts to diminish the service strength of the part.

Thus the conditions for cracking and premature fatigue exists. To reduce cracking you must reduce the stress on the weld joint.

See Article About **Peninsula Metal Fab** Appendix A.

2 – Reduce Downtime by Eliminating Rework (up to 100%)

Customer Comment:
"Despite using preheat cracking persisted on the jet ski mold until we used sub-harmonic energy during welding. Then we put 80-hours of welding with NO CRACKS!"
WesTool

Situation.
Often emergencies are so critical that anything that slows down the repair is unacceptable. In these cases good welding practices like preheating, maintaining proper inter-pass temperature, slow cooling, and post weld stress relief are drastically altered if not skipped completely. Taking short cuts frequently result in cracking upon cool down, or worse, cracking shortly after the repaired part is put back into service. On occasion, even when the above mentioned practices are used cracking still occurs. Re-occurring cracking means scarfing out the cracked area and start the repair process over again. When reworking is needed that's when you really know you have to find some way where you can produce a higher quality weld.

This "ripper shank" lasted less than 4-hours even though preheat was used during the repair. The same ripper wore out after Meta-Lax technology was applied during welding.
Weber Manufacturing

Solution.
When Meta-Lax technology is applied during the welding the weldment "thinks" it's preheated. It's not, but it reacts that way. The Meta-Lax welding procedure is accomplished once again by having the welder increase his weld amps 3-15%. But this time the welder adjusts the weld parameters of weld travel speed, weld deposition rate, and voltage to produce the greatest amount of weld penetration and widest weld bead compared to normal welding. These two traits (deeper weld penetration and wider weld bead) are characteristic of achieving a higher quality, crack resistant weld. Upon cool down the weld metal is much more likely to avoid cracking and therefore eliminate the need for rework.

Preventing Weld Cracking by 50-95%

By applying sub-harmonic energy during welding the "quality" of the weld joint will be higher due to the improved weld bond to the base material which greatly reduces weld cracking issues. Laboratory and field performance have verified this.

The mechanical properties of sub-harmonic conditioned welds exhibit higher ductility (up to 400%) and higher impact (up to 75%), while maintaining the full yield strength of the metal.[2]

Therefore, the performance of the weldment is greatly improved because the whole weld joint becomes resistant to cracking immediately after welding as well as later in service.

See Article About **US Army** Appendix B.

Bonus from Reducing Rework
Morale improves because welders take great pride in their work but only if it is successful.

3 – Reduce Downtime by Performing On-Site Repairs

Customer Comment:
"Recently a couple of badly damaged stellite valve seats were repaired in place ... The job was accomplished by using Meta-Lax thermal stress relieving equipment."
Pennsylvania Power & Light

Situation.
Often a damaged component is taken out of its machine and transported to the maintenance shop because it is believed that the maintenance shop is the only place where a quality weld repair can be achieved. The problems with repairing on-site are usually based on one or more of four reasons: difficulty in working on a component that is part of an assembled machine; the concern for consistent preheating of the welded area; the need for out-of-position welding; or the lack of a practical or economical way to give the welded area a post weld stress relief and apply it without damaging the surrounding parts.

Solution.
Meta-Lax technology is changing where high quality welds can be produced. The Meta-Lax equipment is very portable, weighing 65 lbs. or less, and operates on standard 110 or 220 volt electricity. This makes it easy to take it to the job site and run from a generator. At the job site the force inducer and transducer need to be clamped to the work piece usually within 7.5-feet of the area to be welded. The Meta-Lax technology is then applied during welding.

Even overhead welding is easier using Meta-Lax technology during welding.
LTV Steel

The welder will quickly realize that on-site weld repairs will become much easier. This is based on **Three** important changes:

First: The need to bring the entire welded area to a high preheat temperature will be diminished, although it is still recommend to "burn off the moisture" in the welded areas before starting to weld.

Second: The welder will notice that welding in any position will be easier because the weld seems to be pulled into the weld joint, even when overhead welding.

Third: The entire area will be getting stress relieved while welding. This means that not only will you be reducing the stress in the weldment as the stress is being induced from welding, but you will be stress relieving the entire area, and on many parts the entire part, not just the weld joint. In most cases, Meta-Lax technology applied during welding eliminates the need for post weld stress relief unless tempering is needed.

See Article About **Nondestructive Inspection Service (NIS)** Appendix C.

Bonus from On-Site Welding
Total cost of repair is greatly reduced since you eliminate the cost of disassembly, transportation, and reassembly.

4 – Reduce Downtime by Producing Longer Lasting Repairs (up to 400%)

Customer Comment:
"Since using Meta-Lax, we eliminated cracking in the last 600-700 cross tubes we made over a 4-year period. That's unheard of in our business!"
Corrosion Engineering

Situation.
Once the component begins to crack and weld repair is needed the interval between repairs becomes shorter and shorter. The reason why is because the base material becomes weaker with each weld repair. Therefore it is important to reduce the amount of stress on the weld bead and heat affected zone as much as possible during each repair.

Solution.
When using Meta-Lax technology during welding you will begin to notice that the weldments will have much longer intervals between repairs and therefore will have a much longer in service life. This is due to the gentle vibration that Meta-Lax technology produces will result in a better weld bond to the base material, finer weld grain, and much less tendency for distortion, all of which translate into less stress on the weld bead and HAZ. Occasionally components last five times longer in service (400%) after using Meta-Lax technology during welding.

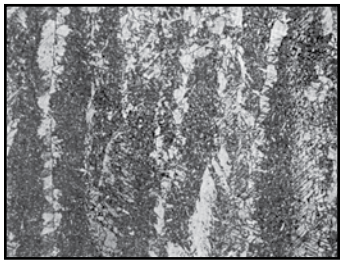
The edge of this bucket now lasts 5-TIMES LONGER (400%) in service since Meta-Lax was added to the welding procedure.
National Steel
Great Lakes Division

Bonus from Longer Lasting Repairs
Improves efficiency and profits since emergency repairs are disruptive for the whole company from top to bottom.

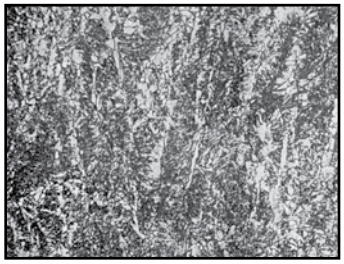
See Article About **Airtex** Appendix D.

Photomicrograph Comparisons

Grumman Aerospace
6061 Aluminum

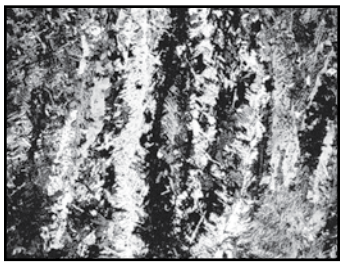


Normal Weld

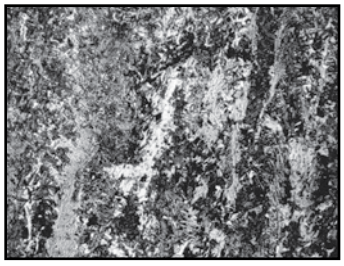


Sub-harmonic Weld Conditioned Weld

Bonal Corporation
A36 Carbon Steel



Normal Weld



Sub-harmonic Weld Conditioned Weld

How Meta-Lax Technology Works As Applied During Welding

According to George Linnert in his Welding Metallurgy handbook, "Vibrating or stirring the metal immediately before it undergoes solidification will act to produce smaller grains."[1] This is clearly evident when Meta-Lax technology is applied during welding.

Meta-Lax technology involves inducing the part to very mild "sub-harmonic" vibrations during welding (see Figure 1). The base material of the part exhibits a higher energy state than normal. The part "thinks" and acts like it is preheated. It is not, but the higher energy state is equivalent to about a 300-F preheat. Like preheating, as liquid metal is deposited Meta-Lax vibrations will gently excite (or pulsate) the atoms of the base material and allow the liquid metal to stay in the liquid state a few seconds longer before solidifying. During this time the weld metal solidifies more uniformly from the root of the weld gradually out to the face. In doing so, the weld profile will look slightly flatter or even slightly concave (see Figure 2). Also, when the liquid weld metal contacts the surface, which is moving in a higher energy state, more centers of freezing will occur when the exact freezing temperature is reached. This translates into a refined weld grain which is an indication of less stress on the HAZ and a highly crack resistant weld (see Photomicrograph Comparisons).

Metallurgical changes.
Ductility and impact values will be higher as a result from applying Meta-Lax vibrations during welding. The higher values are up to 400% and 75% respectively. All other mechanical properties should be about +/- 3% of normal.

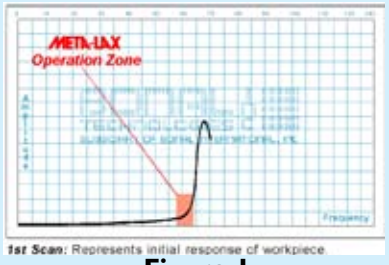


Figure 1

Figure 2

Normal Weld

Sub-harmonic Weld Conditioned Weld

Bonus Benefits

Besides reducing downtime, using Meta-Lax technology during welding should reduce distortion, porosity, undercutting, and spatter.

"Meta-Lax [sub-harmonic energy] is a proven substitute for 80-90% of heat treatment stress relief in metal-working applications."
U.S. Dept. of Energy

U.S. Department of Energy Study
Summary from U.S. Department of Energy

A few years ago, the U.S. Department of Energy sponsored a study into Meta-Lax sub-harmonic energy as used during welding as an "energy savings" invention. Included in this investigation were comparisons between samples that were welded as normal, preheated, heat treat stress relieved and sub-harmonic treated during welding. According to the U.S. Dept. of Energy's own Tech Brief they concluded that "Meta-Lax [sub-harmonic energy] is a proven substitute for 80-90% of heat treatment stress relief in metal-working applications."[2] See Table 1.

Table 1: Data Summary from US DOE Report (#DE-FG01-89CE15412)

A36 Steel, held restrained for 30-days before testing	As Welded (Normal)	Pre-Heating	Heat Treat Stress Relieved After Welding	Sub-Harmonic Energy AFTER Welding	Sub-Harmonic Energy DURING Welding
Tensile Strength (psi)	77,250	70,500	66,750	76,750	76,450
Charpy - (ft-lbs) Weld Zone	36.3	32.2	21.5	31.7	37.2
Charpy - (ft-lbs) HAZ Zone	6.4	6.1	14.1	12.0	11.2

For a full copy of this report contact Bonal.

See Tech Brief by **US DOE** Appendix E.

Acceptable Equipment

"It [Meta-Lax] improves the inconsistencies of the previous resonant-vibration technology by using more efficient, more consistent "sub-harmonic" vibrational energy, which is the optimum vibration stress-relief frequency."
U.S. Dept. of Energy

Meta-Lax® and PPAW® equipment have both been designed to apply Meta-Lax technology during welding.

Not just any vibration producing system will be successful in reducing downtime.

Technology: The system must apply Meta-Lax sub-harmonic energy during welding. This is absolutely critical. If some other vibratory process is applied during welding weld quality will surely be sacrificed and therefore be counter-productive to reducing downtime.

Equipment: The vibration equipment must be accurate and stay accurate throughout the welding. There are two areas especially important to watch for. First, the force inducer (or pulsator) must maintain the desired sub-harmonic frequency throughout the welding to +/-2%. Some force inducers are made using pneumatic or permanent magnets which vary greatly in RPM and therefore should not be used. Also, the non-adjustable, one-size-fits-all force inducers are inefficient from the standpoint that they will give too much energy to the flexible parts and too little to the rigid parts. Therefore these kinds of force inducers should be avoided. Second, the transducer (or sensor), which monitors the amount of deflection of the weldment during treatment, must not lose its accuracy during the vibration process. This eliminates all vibration equipment which is operated using piezoelectric material in the transducer.

Bonal Technologies has designed two product lines ideally suited to apply Meta-Lax technology during welding. The product lines are Meta-Lax® and Pulse Puddle Arc Welding (PPAW)®. Bonal holds the patents for applying Meta-Lax sub-harmonic vibration energy for beneficial gain, including as used during welding, and has not authorized or licensed any other vibratory equipment manufacturer to use this technology.

Conclusion

Meta-Lax technology WORKS and can be very effective in helping you reduce downtime in any one of **FOUR** different ways:

1. From welding up to 25% faster.
2. To reducing rework.
3. To performing on-site repairs.
4. To producing repairs which last up to five times longer.

Isn't it time you let the new advances in welding, namely Meta-Lax technology, assist you in reducing emergency downtime?

Call Bonal Technologies at 1-800-META-LAX or e-mail at info@Bonal.com.

Customer Comments:
Utilizing Meta-Lax a quality weld was laid on the first attempt. In comparison with historical records, in which up to 20 working days were required to complete the welding, the equipment worked well.
U.S. Navy

The teeth of this bucket used Meta-Lax technology to make them crack resistant which resulted in a 300% increase in service life.
Kennecott

References:

1. Linnert, G.E. 1994. Structure of Metals. Welding Metallurgy – 4th Edition. AWS.
2. Aellen, J. 1989. The Meta-Lax Method of Stress Reduction in Welds. DE-FG0189CE15412. U.S. Department of Energy.

Appendix:

See Article About **NASA** Appendix F.

A. Peninsula Metal Fabricators
B. US Army
C. Nondestructive Inspection Service (NIS)
D. Airtex
E. U.S. DoE
F. NASA

Appendix A

Shop Finds the 'Holy Grail' of Welding

A metal fabrication shop looked for a secret weapon to give it an advantage over the competition and found it with subharmonic technology

Welding with subharmonic technology gave Peninsula Metal Fabrication an edge over their competition

Peninsula Metal Fabrication, San Jose, CA, wanted to beat its competition. A request for proposal pushed it into an unfamiliar technology and gave it an edge. The company makes advanced precision assemblies. It is known for expertise with welding frames, chassises, and sheet metal.

Peninsula Metal management attends trade shows to stay abreast with technology. At the American Welding Society show in Dallas, the Peninsula Metal team saw a demonstration of Pulse Puddle Arc Welding from Bonal Technologies, Inc., Royal Oak, MI. Pulse Puddle Arc Welding – PPAW – helps solve welding distortion and cracking by using subharmonic vibration technology. Using its Meta-Lax vibration stress-relief technology, Bonal developed the PPAW product line specifically for welding and fabricating .

Two weeks after the show, Peninsula Metal was preparing a quote and found the request for proposal specified vibratory stress relief during welding. Peninsula Metal did not have a system to provide this type of stress relief. The company usually sent parts out for heat treatment, but it was time-intensive, expensive, and not possible during the welding process.

To qualify for the quote, Peninsula asked Bonal Technologies for a PPAW unit to test the technology. PPAW technology promised less straightening, rework, preheat, and fewer secondary steps.

The "Wow!" Factor

"We had customers interested in finding a weld shop with subharmonic stress relief technology. We were amazed at how the technology worked," Paul Eischens, Peninsula Metal weld manager, said.

"The bulk of our work is stainless steel. We tend to get a lot of distortion and squareness issues. We hoped the product would help with distortion control. We not only found we got less distortion, we also got better penetration. PPAW helped us speed up production time and cut down on our setup time."

PPAW creates a pulsating weld puddle while the liquid weld metal is deposited. An optimum energy level pulsates the weld puddle. The puddle pulsation creates a fine weld grain structure and more homogeneous mix with fewer columnar structures. Fewer columnar structures improve the weld metal's mechanical properties, making the metal more ductile – up to 400 percent – while increasing impact strength up to 75 percent for better crack resistance.

With increased weld speed, the company reduced overtime 10 to 15 percent

"We're fortunate that upper management is forward-looking with a long-term view of our business. When we saw the benefits of PPAW, they said we needed one for every bench," Jim Scocca, Peninsula Metal plant manager, said. "We now have six units."

The system's wand controls the pulsator speed and pulse

Continued on page 18

level adjustment controls. A sensor is mounted to the workpiece that monitors and sends the pulse strength to the control system. The wand lets the operator adjust the pulse rate for welding. The pulsators, which are clamped to the part, fixture, or table, are available in four sizes to treat weldments weighing up to 40,000 lb.

"The pulse system played a key role in making [us] more competitive since it saved as much as 15 percent on finish machining . . . "

Mobility

Peninsula Metal has the units on individual carts for mobility. They move from bench to bench around the shop. Peninsula Metal sets the parameters so welders don't have to make changes.

"We clamp it to the table, press the button, and it works," Eischens said. "Originally we thought the technology would be cumbersome, but I was surprised at how easy it was. Within 24 hours it was up and running. We're a lean manufacturing shop and this technology falls in line with our methodology. After minimal training, our welders do the process themselves."

The system gives the shop a competitive edge, offering more flexibility and faster production.

"The quality of our welds is so much better it's like night and day," Eischens said.

"Faster speed, better penetration, and less straightening are the holy grails for improving welding," Scocca said. "We have less straightening time after the weld because the frame is stress-relieved during welding. Our welds are 15 to 20 percent faster. We can increase weld speed because of the better penetration."

The pulse system played a key role in making Peninsula Metal more competitive, since it saved as much as 15 percent on finish machining now that its weldments are stress-relieved during welding. With increased weld speed, the company reduced overtime 10 to 15 percent and decreased production costs two to three percent.

"With PPAW our quotes beat the competition. We do less straightening and involve less labor," Scocca said. "We know weld quality is much better with less effort. We plan to retrofit our robotic welder with the system, too."

Chamfering and grinding of the base were reduced, but the welders get the same amount of weld penetration.

"Our quotes reflect a more competitive cost without increased lead time," Scocca said. "The heat-treating cost factor is gone. On average we see about a three percent savings per frame. Since we're in a hyper-competitive environment, this means the difference between getting the job and not getting it."

Input from the Floor

One of the significant factors in adding more PPAW units was welders' input.

"Our welders were surprised since they hadn't heard of this technology," Eischens said. "We performed test cases where we welded with and without the system. There was a noticeable difference. That convinced us to buy more systems."

One of Peninsula Metal's customers orders speaker grids for large concert venues and churches. The grids are made from 1' aluminum bar and welding the grids in the usual manner created distortion.

"Implementing PPAW made a huge difference in the quality going out the back door," Eischens said. "Our customers definitely noticed."

Data from Bonal shows PPAW welds have almost 22 percent ductility value, compared to 5.5 percent ductility for welds made without the system.

Plates welded with PPAW have been found to be 307 percent more ductile than untreated weld plates.

The Pulse Puddle Arc Welding system was so successful in manual welding that Peninsula Metal Fabrication will be installing it in its robotic welding cell

According to a U.S. Department of Energy 1989 report, standard mild steel welds have a weld joint strength of 45,800 psi. By comparison, weld joint strength was 89 percent higher – 86,500 psi – when subharmonic technology was used during welding. *Bonal Technologies*

www.rsleads.com/707mn-201
or Circle 201 for more information

What do you think?

Will the information in this article increase efficiency or save time, money, or effort? Let us know by e-mail from our website at **www.ModernApplicationsNews.com** or directly e-mail the editor at **pnofel@nelsonpub.com.** ■

Appendix B

META-LAX® FACTS

Watervliet Arsenal Volume 2, No. 3

Meta-Lax Helps Military Stay on Target

The **Watervliet Arsenal** in New York state produces nearly all of the gun barrels for large caliber weapons used by the U.S. Military, including mortars, field and tank cannons as well as the giant 16-inch guns of battleships. The barrels are forged straight cylinders which are bored on the inside and turned on the outside. But during the heat treat metal hardening process, residual stress develops in the metal and the barrels become distorted and are no longer straight. For one weapon, the 120 mm smooth-bore mortar, the facility was forced to scrap over 50 percent of the barrels due to this distortion problem.

In an effort to correct this recurrent warping problem, the Arsenal tried various forms of stress relief including thermal stress relief. But according to Tim O'Connor, a mechanical engineering technician for Benet Laboratories at Watervliet, "Nothing really worked consistently. And thermal stress relief at best was only a hit and miss process. Sometimes it seemed to work but most of the time it didn't."

It was Tim O'Connor who brought Meta-Lax to the attention of Watervliet Arsenal in 1991. "I came across an article about Meta-Lax in a metalworking trade publication and thought it might be a solution to the distortion and scrap problem we were having with the 120mm mortars," said O'Connor. "I called Bonal Technologies to get more information about the Meta-Lax process and learned to my surprise that we already had an older Model 2200 unit at the arsenal. However, I discovered that because of an earlier poor experience with a competing vibratory system, the Bonal unit was not used.

"After some searching I found the unit sitting idle in a corner. So I enrolled in one of Bonal's regularly scheduled training classes. The training was excellent - both on the scientific level and on the everyday level. The staff explained not only how the equipment works but also gave clear explanation of why it works."

Under O'Connor's guidance, the arsenal first used its existing Meta-Lax unit to stress relieve the 120mm mortar barrels. "The results were astounding," said O'Connor. "We saw our scrap rate go from 50 percent to 0 and stay there. What's even more amazing is that we were able to accomplish this feat at a fraction of the cost and time required for thermal stress relief. We achieved a $230,000 annual savings in energy costs for that one weapons system alone. And we've cut time required for the stress relief process from several hours in a furnace to 30 minutes on a Meta-Lax table."

Reduced scrape rate from 50% to 0.

"We achieved a $230,000 annual savings in energy costs for that one weapons system alone."

The Arsenal now has been using Meta-Lax daily for nearly four years. And according to O'Connor, "Meta-Lax has performed flawlessly. It's worked so well that we've purchased two of the computerized Meta-Lax units, written Meta-Lax into our production process plans and expanded its application. In addition to the 120mm mortar, we now use Meta-Lax to stress relieve the barrels of the 90mm mortar and the breach rings on the 105mm Howitzer.

"We're currently looking at the feasibility of also using Meta-Lax on our larger guns," O'Connor added. "The barrels on these guns average anywhere from 12-to-20 feet in length and have to be hydraulically pressed straight when they become warped during the manufacturing and heat treat process. This pressing process is very time consuming and has to be repeated every time metal is worked on the barrel. If we can develop a method for Meta-Laxing these barrels, then we could save a lot of time and money."

The Arsenal has also used Meta-Lax for weld conditioning on the base plates for mortars. "We were having a problem with welds on the base plate cracking," said O'Connor. "We were finding anywhere from 40-to-50 indications on each base plate which required re-welding. But by using Meta-Lax to condition these welds, we've reduced the number of indications to 2 or 3 on a really bad day."

In today's business battleground, the quality of a company's tool and products need to match its aim if it's going to hit its target. While Meta-Lax is helping the military reach its target, this same technology can also help your company achieve its profit objectives.

BONAL TECHNOLOGIES, INC. SUBSIDIARY OF BONAL INTERNATIONAL, INC.

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BONAL INTERNATIONAL, INC.

Good Vibrations Deliver Superior Weld Repairs

For an inspection service, locating cracks in welds can be fairly simple, but performing quality repairs to pieces of equipment either too large or complex for normal heat treatment or weld stress relief, tuning in good vibrations is essential for good repairs.

Nondestructive Inspection Service, Inc. (NIS) (Hurricane, WV) assists in repairing its customers' manufacturing equipment the quickest way possible. Frequently inspecting, locating, and repairing cracks in equipment and in welds are major tasks.

For example, NIS needed to repair a screw-type conveyer that had cracked in the center of the stainless steel conveyer piping – 30" dia. and 30' long – used for moving material. NIS also needed to make the repair without warping or bowing the pipe. Time did not allow for the usual heat transfer in the weld repair.

Another customer had several large cylinders, each weighing 35,000 lb. and measuring 42" dia. with seam weld cracks more than 20" long. In the past, only a lengthy heat-treat stress relief process was used to repair and stress relieve these repairs. The entire heat-treatment of such large cylinders took a minimum of 30 hours, including 8–12 hours to bring metal up to temperature, another 8–12 hours of welding or holding heat at temperature, and a final 8–12 hours of cool-down.

Using sub-harmonic vibrations at the time weld repairs are made has significantly shortened turn-around time for a West Virginia testing and repair facility.

Repair And Relieve

For maximum efficiency, NIS proposed welding and stress relieving at the same time, in a single operation. "After we analyze and diagnose problems, we need to help our customers make repairs in the best and fastest way possible," says NIS's Ed Hauldren.

To accomplish these simultaneous operations, NIS uses Bonal Technologies, Inc. (Royal Oak, MI) Meta-Lax® product, which relieves thermal stress within metal components and welds by using nondestructive, highly efficient subharmonic vibrations during welding to prevent distortion, cracking, and weld degradation.

The Bonal process meets the quality standards of thermal stress relieving techniques and takes less time without the heat-treat side effects. It also has no part size or weight limitations and is portable for on-site treatment.

"In the past 4 years we have relied heavily on Bonal and use its proven technology for weld repairs and stress-relieving," said Hauldren. NIS maintains two units at its headquarters and rents additional units when required for field repairs.

The Process

"Companies that Meta-Lax weld condition their welds have less cracking, distortion, porosity, and shrink-line effect," maintains Tom Hebel, vice president, Bonal. "They may also use one-third of the normal preheat temperature and…weld easier and faster."

During the Meta-Lax process, the operator clamps a force inducer, or vibrator, onto the workpiece. The operator then uses instrumentation that measures vibratory amplitudes of the workpiece and determines the present harmonic frequency curve. The initial curve represents the "false" harmonic frequency because the metal is stressed. After the force inducer vibrates the workpiece for about 20 minutes at a frequency corresponding to one-third of the height of the stressed harmonic amplitude, the harmonic frequency permanently shifts. The new curve is a true reading, indicative of the metal's non-stressed state.

Vibrating the metal while the liquid weld solidifies produces a finer, more uniform grain structure because of the increased accelerated motion at the time of weld solidification, advises the manufacturer. "A finer, more

uniform weld grain structure is a clear indication of improved mechanical properties," says Hebel. "Ductility and impact values of welds using the Meta-Lax weld conditioning process increase as much as 400% and 75% respectively over normal welds," according to Hebel.

Repair Results

"Had our conveyer tube customer repaired the conveyer tube without conditioning, the pipe would have bowed...under normal welding circumstances," says NIS's Hauldren. "But when the repair was completed with Meta-Lax the deflection was measured with a wire stretched from one end of the pipe to the other; the bow in the tube was less 1/8". The repair and the weld conditioning as well as the stress relief were a great success.

"We save our customers' time and money..."

"If we used traditional heat to stress relieve on something this large it would have taken at least 24–30 hours in addition to the initial welding process and would not have created as strong of a weld," he notes.

"After the initial weld repair, the weld was ground flush and the stress relief was also completed at the same time. The Meta-Lax process gave NIS the ability to save our customer valuable time because the crack could be repaired, the weld prepped (ground flush) as well as stress relieving the whole workpiece all at the same time," adds Hauldren.

"The main reason we use Meta-Lax vs. heat-treat is the time and money savings. In just 30 hours our cylinder-repair customer was back up and running in comparison to the 50 hours it might have taken using a traditional heat-treat stress relief process. We save our customers' time and money....."

NIS consistently meets its goals of identifying the problems, suggesting solutions, and implementing the solutions to get its customers back online in the minimum amount of time and with better weld quality. *Bonal Technologies, Inc.*

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Appendix D

META-LAX® FACTS

Airtex, Inc.

Meta-Lax Pumps New Life Into Dies At Airtex

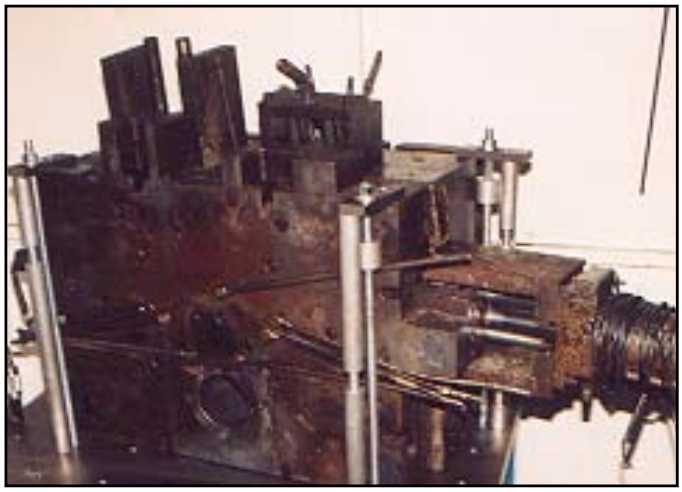
Located in rural southeast Illinois is the world's leading independent manufacturer of aluminum die casted water and fuel pumps for the automotive industry. Airtex, Inc., Fairfield, IL, has focused on this small market niche. It maintains a high standard of customer satisfaction through design, service, quality, and availability.

Last year Airtex improved its internal efficiency by installing a Meta-Lax stress relief center which included a Meta-Lax stress relief system and a 3-ft x 4-ft vibration table platform. Since then Ray Troup, Die Cast Tool Engineer concludes that "It would be a struggle to take the Meta-Lax machine out now. We couldn't get along without it."

To date, Airtex has Meta-Lax treated all 150+ die sets that are used in their aluminum die casting operations. Initially Ray justified the cost of the Meta-Lax system by the expense of sending inserts 135 miles to St. Louis for stress relief.

Now after a year of getting comfortable and confident with Meta-Lax processing, Airtex has a new rule: *All aluminum die cast tooling must be Meta-Lax treated at a maximum interval of 20,000 shots or after every repair or at every model changeover, whichever comes first*. "There are no exceptions," emphasizes Ray.

When asked about performance Ray explained about an intricate die with a high attrition rate due to its shape. Normally the new die component would last 12,000 to 15,000 shots before heat checking would begin to occur. If they were lucky the insert would last 70,000 shots before being replaced. Meta-Lax was applied to the next new set of inserts and at each model changeover time which is between 10,000 and 15,000 shots, and hot oil was circulated through the die. "The die is at 170,000 shots now and we haven't touched it for maintenance expect for applying Meta-Lax," Ray explained. "I fully expect to triple the die life from this die."



No exceptions - Meta-Lax is the rule at Airtex. Triple die life is expected even from high attrition dies.

By having the Meta-Lax stress relief center the stress relieving is convenient and easy. "It really only costs us about 10 minutes of a man's time for stress relief," said Cliff Reever, Tool & Die Maker. "We don't have to sit there and watch it." The time needed for the full Meta-Lax treatment is about one hour. Both Ray and Cliff are very impressed with the ease of operation of the equipment.

"I fully expect to triple the die life from this die"

Furthermore, Airtex requires Meta-Lax to be used during welding (Meta-Lax Weld Conditioning) on most die tooling. After a year of Meta-Lax application Ray has seen a dramatic change in the weld repair department.

"Meta-Lax is the best thing to come into the weld shop since the welder! 90% of the weld repairs stay in-house now, and 75% of that is due to Meta-Lax. That's because the repairs are less severe and the welders are more confident in the quality of the weld that they can deposit when they use Meta-Lax Weld Conditioning," Ray observes.

"We have cut our repair time down by over 60% on many dies! What took two weeks in the past takes two days now. What took 24 hours in the past takes four hours now. And both weld porosity and distortion have nearly been eliminated," Ray commented.

When asked about cost savings Ray just laughed. "Whew, I can't begin to tell you!"

Roy Xanders, Executive Vice President, is also impressed. He makes a special point to take guests around his maintenance area to show their Meta-Lax stress relief center. This serves as a good example of their ongoing efforts to implement new technology which ultimately benefits their customers.

Next time you are working on a car engine and see the water or fuel pump, note that it is a very high quality aluminum die casted part. Chances are overwhelming that it was made by Airtex.

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Appendix: E

METAL CASTING

Success Story

META-LAX® STRESS RELIEF PROCESS

Meta-Lax Stress Relief Process Greatly Reduces Energy Consumption and Eliminates Pollution

Benefits

- Reduces energy consumption by up to 98% compared with natural-gas-fired heat treatments
- Through 2001, has saved 98.7 trillion Btu cumulatively
- Operates on standard line voltage
- Through 2001, has saved over $342 million from reduced natural gas usage
- Requires nearly 98% less time for stress relief
- Through 2001, has reduced carbon emissions by over 1.57 million tons.
- Reduces production costs and weld cracking by approximately 95%
- Offers comparable or better work-piece performance than thermally stress-relieved parts
- Is portable and lightweight for on-site treatment
- Has no part size or weight limitations

Applications

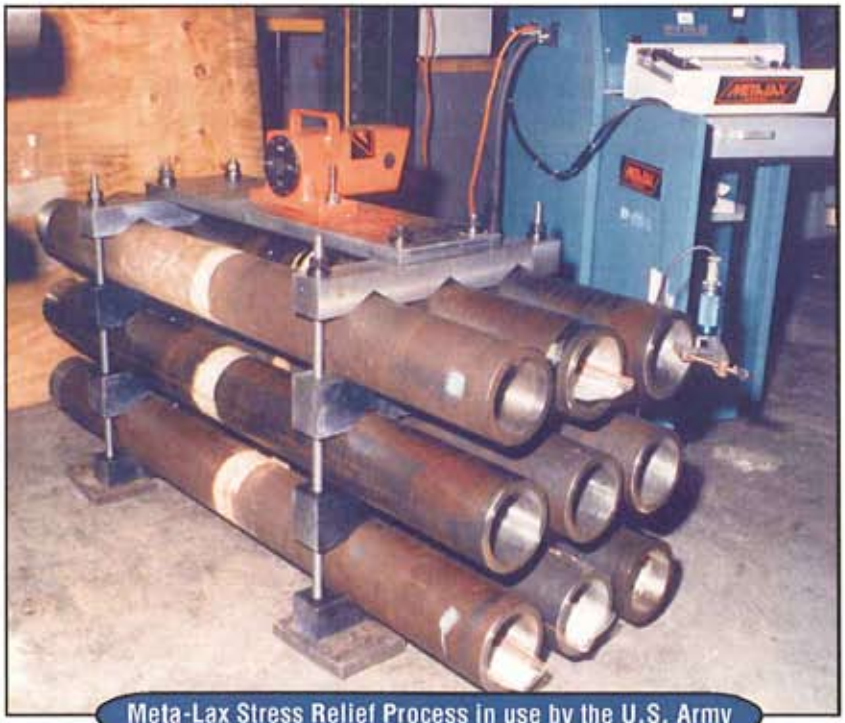
Metal fabrication and machining industries; applicable to castings, forgings, weldments, and metal plates.

"The DOE grant has given us credibility, to a certain extent, away from being an unknown, unendorsed company, that just created a better mousetrap."

– Tom Hebel
Vice President
Bonal Technologies, Inc.

It's nearly impossible to go through an entire day without coming in contact with an item that was produced from metal tooling. The cars we drive, the appliances we use, and the water heaters that warm our homes are all manufactured using metal tooling. The manufacturers of these products rely heavily on tooling for manufacturing quality products. And, consumers expect these products to last.

Items that have been manufactured through fabricating, forging, casting, or machining are typically stress-relief treated to ensure that the metals hold up under the pressure of daily wear and tear. Thermal stress is the result of a sharp temperature drop during metal processing and it can create distortion and premature cracking. "Stress relieving" reduces these problems. However, the most common method of heat-treatment stress relief has problems of its own. It is costly, both in terms of time and energy. It may take hours or days to treat metal items in a furnace, and those hours and days of furnace time equal large amounts of fuel that must be burned.



Meta-Lax Stress Relief Process in use by the U.S. Army

OFFICE OF WEATHERIZATION AND INTERGOVERNMENTAL PROGRAM
ENERGY EFFICIENCY AND RENEWABLE ENERGY • U.S. DEPARTMENT OF ENERGY

Technology Description

With a grant from the U.S. Department of Energy's Inventions and Innovation Program, Bonal Technologies, Inc., has created and patented the Meta-Lax process, which relieves thermal stress within metal components by using nondestructive, highly efficient subharmonic vibrations to prevent distortion and cracking. The 1989 grant gave Bonal Technologies the chance to refine and prepare its process for the marketplace, including third-party documentation.

In the Meta-Lax (metal relaxation) process, the operator clamps a force inducer (vibrator) onto the object and, using instrumentation that measures vibratory amplitudes of the atomic lattice, determines the present harmonic frequency curve. The curve represents the "false" harmonic frequency of the stressed metal. After the force inducer vibrates the metal for about 20 minutes at a frequency corresponding to one-third of the height of the stressed harmonic amplitude, the harmonic frequency permanently shifts. The new curve is a true reading, indicative of the metal's nonstressed state.

Meta-Lax is a proven substitute for 80% to 90% of heat-treatment stress relief in metal-working applications. It improves the inconsistencies of the previous resonant-vibration technology by using more efficient, more consistent "subharmonic" vibrational energy, which is the optimum vibration stress-relief frequency. This process treats a wider variety of work pieces with a versatile, portable unit and yields results much more quickly than conventional, stationary heat-treating furnaces. Conventional heat treatments may require over 6 hours while the Meta-Lax process requires an average of about 30 minutes.

System Economics and Market Potential

The Meta-Lax process was commercialized in 1991, and approximately 1300 units are currently operating in the United States. Payback time is estimated to be from 6 to 9 months. The Army reports a $230,000 annual return on its investment in this technology.

Bonal Technologies develops subharmonic vibrational metal stress-relief and weld-conditioning technology. Bonal Technologies employs 23 people and has annual sales of approximately $2 million.

The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and to conduct early development. Ideas that have significant energy-savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

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META-LAX® FACTS

NASA Langley Volume 6, No. 1

Meta-Lax Proves Beneficial to NASA

When **National Aeronautics and Space Administration (NASA)** engineers prepare for a test, they do their homework. As a result, they discovered Meta-Lax stress relief and weld conditioning was the additional edge they needed to solve tough welding distortion problems.

"We use Meta-Lax whenever we anticipate a weld distortion problem which may cause an out of dimensional tolerance condition," said Gerald Miller, the Standard Practice Welding Engineer at NASA's Langley Research Center in Hampton Virginia.

According to Miller, "Meta-Lax has been very beneficial to NASA and is used frequently. The fabrication shop uses it for weld conditioning and stress relieving, while the machine shop uses it to stress relieve mill induced rolling and process machining stresses. Three years ago on a large facility renovation job we used three Meta-Lax units at once," he said.

"I think of Meta-Lax as an extra trick up my sleeve for a higher quality product. I use it along with weld bead sequencing, back stepping techniques, preheating and proper fixturing," Miller added.

Recently, NASA applied its Meta-Lax Model 1300 for weld conditioning to a project constructed of 304 stainless steel and A500 Grade B mild steel tubing for a calibration rig.

The calibration rig is used to calibrate the wind tunnel model balance before it is installed on an aircraft model. The balance senses the simulated in flight loads on the model as it is manipulated inside the wind tunnel airstream. The six load readings are critical information to an aircraft's flight characteristics.

This particular model balance is used in the National Transonic Facility (NTF) typically operating at a temperature of -250° F. Therefore this unique balance calibration rig must simulate the temperature of this wind tunnel and the in flight loads the model may encounter.

NASA's Langley Research Center uses Meta-Lax weld conditioning on a wind tunnel model balance calibration rig.

The tunnel, an ASME code stamped pressure vessel, employs an atmosphere of liquid and gaseous nitrogen to simulate a high density viscous flow medium. The calibration rig was Meta-Lax weld conditioned and stress relieved, resulting in a dimensionally stable project.

"I think of Meta-Lax as an extra trick up my sleeve for a higher quality product."

"Since we began using Meta-Lax, we have experienced the ability to hold dimensional tolerances on weldments and machined parts as never before. It is also obvious the penetration of the Flux Core and Shielded Metal Arc Welding processes into the weld joint are enhanced when weld conditioning is used. This phenomena helps reduce weld distortion due to residual stresses because we weld with less heat input. The weld bead tends to lay down flatter and more even. Impurities and flux inclusion seem to be less too. Overall we have a better product," said Miller. "At NASA, Meta-Lax has repeatedly proven it can handle the pressure."

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