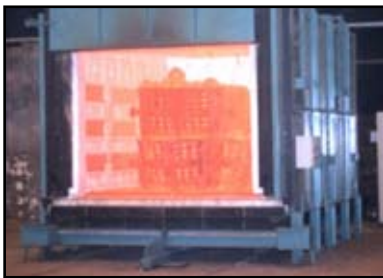


# 3 MAJOR PROBLEMS WITH THERMAL STRESS RELIEF AND HOW TO OVERCOME THEM

By Thomas E. Hebel



*Past standard becoming more and more undesirable.*

## **Thermal Stress Relieving**

Specifically three major problems are associated with thermal stress relief. They are cost, time, and treatment distortion. **This paper explains why these problems seem to be much more severe today than in the past and how to overcome them.**

Before details are presented on how to overcome problems associated with thermal stress relief two things must be mentioned on behalf of the heat treating industry. First, thermal stress relieving has been used since about 1912. During this near century of use thermal stress relief has become the “standard” practice of stress relieving where it has achieved, in most cases, a high degree of success. Success is measured by controlling distortion and minimizing premature fatigue. Second, the “problems” associated with thermal stress relief are usually not the fault of the heat treat service provider but rather have resulted from the side-effects of using “heat.”

Taking the First Step.

**The first step in overcoming these problems is to realize that in most industries technological advancements have taken place.** For example, during this same time period we have seen the calculator replace the slide-rule and the photo copier replace carbon paper. Likewise, in the area of stress relief there are alternatives that have been proven to be as effective as thermal stress relief yet without the negative side-effects that are caused by heat. These alternative stress relief processes include Meta-Lax® (a sub-harmonic vibration process), natural aging, cryogenics, stretch, compression, and peening.

Following this discussion I will provide information on Meta-Lax® technology with emphasis on how industry is using this technology to overcome the problems associated with thermal stress relief. I will also summarize the other stress relief processes. In addition, there is an inset article which explains how Meta-Lax works. But for now, it may be worthwhile to know that thousands of quality conscience organizations are using the patented Meta-Lax to overcome thermal stress relief problems including NASA, US Navy, Northrop-Grumman, and General Motors.

### **About the Author:**

Thomas Hebel, Vice President of Bonal Technologies, Inc., has over 30 years experience in the vibratory stress relief industry. During this time he has written over 15 feature articles and has given over 50 speeches. Mr. Hebel can be reached at [thebel@bonal.com](mailto:thebel@bonal.com).

*The new “energy surcharge” disguises the real price increase of thermal stress relief.*



*No more free trucking*  
**Transporting Material**

## Problem #1 – Cost

### **Situation**

Most industrial stress relief furnaces are fueled by natural gas. Natural gas is the preferred energy source because of its cleanness and high efficiency<sup>1</sup>. However, **the price of natural gas has tripled since 2000 and shows no sign of let up for years to come<sup>2</sup>**. This is due to the increasing demand for natural gas from consumers as well as from an increasing number of power plants switching from coal to natural gas. The pipeline infrastructure is not growing as fast as demand, new wells are being drilled but at a slower rate than the existing ones are drying up<sup>3</sup>, and the international demand for natural gas is growing at a dramatic rate<sup>4</sup>. One thing is certain the heat treater will pass along the price increase to its customers.

### **Pay More, Get Less.**

In an effort to minimize the appearance of the real cost increase for stress relief heat treaters have distributed cost increases over other areas, plus added new charges. They are:

1. Increase the price of thermal stress relief.
2. Increase the price of secondary steps like blasting and straightening.
3. Add a charge for what was once “free” trucking.
4. Add a new charge called “energy surcharge.”

## Problem #2 – Time

### **Situation**

The time it takes to thermally stress relieve an average work piece is about 1 to 2 days. In the past, you could simply add a day or two and that was the time you planned on for the stress relief service. Not anymore. These days it seems that the heat treaters take a whole lot longer for their service, even 3-14 days longer. **Most people feel they are at the mercy of the heat treater for a prompt delivery** which makes the time needed for stress relief totally unpredictable.

### **Timely Service Unlikely.**

Heat treaters are becoming more efficient to help themselves save money. In doing this they have adopted two new practices which ultimately adds time to their service and thus to your production. Here are the two new practices.

1. Schedule pick-up and drop-off of parts at their convenience, not yours. Even if you are now paying for their trucking services, they will plan a day and route that will minimize their trucking expenses which will reduce their costs for diesel fuel. That’s a good way to save themselves money, but it still adds time to your production.
2. Wait for a full or near full load before starting the furnace. This is good for efficiency but it destroys your production time.

*Higher efficiency for the heat treater adds to your production time.*



*A heat treater's nightmare due to extreme differential thicknesses.*

**Beiter Mold**

## Problem #3 – Treatment Distortion

### **Situation**

Metal is naturally susceptible to treatment distortion when “heated.” No doubt certain alloys and workpiece configurations are more susceptible than others. But even so, you have probably noticed that treatment distortion is much more of a problem now than it has ever been in the past. You’re right.

### **Severe Distortion the New Norm.**

For efficiency when operating the furnace heat treaters have expanded two practices that were moderately used in the past. Yet both contribute to excessive distortion on many metal parts. (Keep in mind that whenever a part is straightened stress is being induced right back into the part.) Here are the two expanded practices.

1. Stacking parts during thermal stress relief. Stacking often leads to distortion simply because the weight of the part is a downward force. The strength of the part at an elevated temperature is usually about 50 percent of its strength at ambient temperature but its weight is still the same. Then **when you consider the weight of other parts which are stacked on top of it you realize that there could be a substantial force being applied on your part.** The higher the pile the more likely the distortion. Therefore distortion will result unless supports are evenly and completely distributed below each part being heated.
2. Filling the furnace to near capacity. Filling often requires a wider “thickness” differential in the furnace. If your part happens to have thinner sections than other parts, this could mean that your parts will be subjected to too much time at an elevated temperature, which would lead to excessive heat and thus lead to excessive treatment distortion (and possibly changes in mechanical properties).

## Other Annoying Problems

There are several other problems that occur from using thermal stress relief which may be major depending on the part. These problems include changing of the mechanical properties including hardness, softness and strength, the need for blasting, re-machining of distorted sides, re-layout, cleaning of holes and re-threading tapped holes, thermal cracking, and scrap. Then there is always the consideration of the physical limitations of the furnace capacity namely size, weight and location.

## Meta-Lax® - An Alternative Stress Relief Process



Meta-Lax® Stress Relief -  
the New Standard  
Norbert Industries

Meta-Lax is a sub-harmonic vibratory stress relief process that was developed in a planer-mill machine shop owned by Bonal Technologies, Inc. of Royal Oak, Michigan, USA. Our planer-mills varied in cutting surface up to 36-ft in length. This gave us firsthand experience dealing with the effects of stress on metal and ability to determine what works and what does not work for stress relief. The benchmark we used for comparison was thermal stress relief.

**In order for Meta-Lax stress relief to be considered “successful” we insisted that Meta-Lax treated parts had to meet or exceed the performance of thermal stress relieved parts in distortion control following machining and fatigue life, and do it on a consistent basis.** See inset article for “How Meta-Lax Works”.

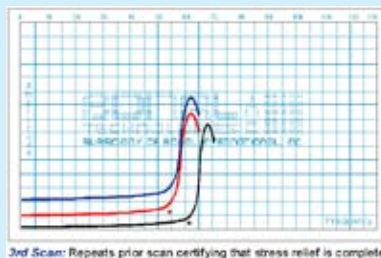
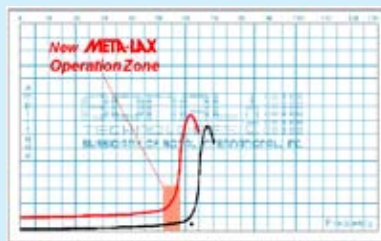
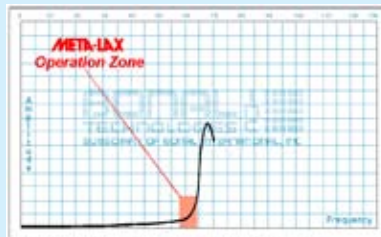
### How Meta-Lax® Works

All metal structures exhibit harmonic and non-harmonic behavior (1st Scan). A metal structure that contains thermal stress (i.e. stress that has been caused from a thermal shock) displays its harmonic curve at a frequency that is out of phase from its natural frequency location. The Meta-Lax process vibrates the metal workpiece at its sub-harmonic energy level (see 1st Scan).

The sub-harmonic zone is optimum energy level when using vibrational energy to stress relieve metal<sup>13</sup>. Sub-harmonic energy is defined as the leading portion of the harmonic curve.

The exact height within the sub-harmonic zone will vary depending on the metal alloy of the parts being treated. By applying sub-harmonic energy for a period of between 15 and 60 minutes, pockets of high stress are redistributed, thereby reducing the effects of thermal stress. Graphically, the harmonic curve shifts over slightly as thermal stress is being neutralized during the process (2nd Scan)<sup>14</sup>. Upon further

Meta-Lax treatment in the sub-harmonic zone there will come a time when the harmonic curve will no longer shift, but rather begins to repeat. When the harmonic curve repeats its previous scan stress relief is COMPLETE (3rd Scan).



Initially we tried using the harmonic peak energy level for stress relieving thinking that we needed to pound the stress out of the metal part. Some people refer to this as the “resonant-vsr” method. However, we found that this at-peak approach did not produce consistent results so we kept researching. Finally we began to use an energy level that was before the harmonic peak (hence “sub-harmonic”). When we applied sub-harmonic energy we witnessed that the metal responded extremely well, achieving excellent distortion control consistently.

In developing the Meta-Lax step-by-step process we also discovered that we could determine when stress relief is complete. This eliminated guessing and assured consistently effective results.

Since its development Meta-Lax processing has been used by the metalworking industry to overcome the major problems associated with thermal stress relief.

This is what industry has found:

## Solving the Cost Problem

The cost of applying Meta-Lax stress relief is usually 90-95% LESS than thermal stress relief.

### **Customer Comment:**

*"We've eliminated all the costs and quality problems associated with heat treating."*

**Giddings & Lewis**

These savings are based on the comparison of treatment costs plus all of the other "associated" costs that must be paid when a particular process is applied.

### **Cost of Meta-Lax Stress Relief Includes:**

1. Cost of 1-man-hour average (part-time).
2. Cost of 1 hour of electricity usage (same usage as a coffee pot).

### **Cost of Thermal Stress Relief Includes:**

1. Cost of stress relief treatment.
2. Cost of "energy surcharge."
3. Cost (per mile expenses) to truck parts to heat treater and back, often making two trips per part.
4. Cost (man-hours) to truck parts to heat treater and back, often making two trips per part.
5. Cost of secondary steps like blasting and straightening, which are usually not needed when using Meta-Lax.
6. The cost of tearing down the set-up and putting it back up when the part returns for finish machining.
7. Cost to re-machine distorted sides before finish machining can be performed.
8. Cost of additional paperwork and scheduling when sending parts out of plant.



*Eliminated thermal stress relief costs.*

**Overhead Conveyor**

It is common to realize a 6-9 months return on investment with Meta-Lax equipment.

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

### **Cost Saving Bonus**

Plan on winning a few more jobs when using Meta-Lax simply because your new quotes will reflect a total cost for stress relief that will be 90-95% less than in the past!



**Customer Comment:**

*"Whenever you send parts out you are at the mercy of someone else. With Meta-Lax we can schedule tighter and with confidence knowing that the parts will be done."*

**Corrosion Engineering**



*Saving more than 98% stress relief time.*

**Steward Machine**

## Solving the Time Problem

Meta-Lax stress relief typically takes 30 minutes to 2 hours. This means that **Meta-Lax is 8-48 times FASTER than thermal stress relief treatment**, and even faster when you consider transportation, scheduling delays and other steps that slow down production.

Actual processing time for Meta-Lax stress relief will depend on material classification, weight, size, and amount of stress in the part. Only very large and/or heavy parts need more than two hours for Meta-Lax stress relief.

The actual time that the Meta-Lax equipment operator would need to spend on stress relieving the parts is typically less than 15 minutes. This is based on 8-10 minutes to set the part on rubber pads, and attaching the Meta-Lax force inducer and transducer on the part, 2-3 minutes to "scan" the part and set in the proper sub-harmonic stress relief zone, then one minute periodically to scan the part until the harmonic curve repeats at a new frequency location. While Meta-Lax processing is in its "dwell time" (which varies from 15-60 minutes) the operator can do something else in the area, which means that Meta-Lax stress relieving is really "part-time" work.

The actual time to Meta-Lax stress relief would be even less if the computerized model of Meta-Lax equipment were used.

### **Time Saving Bonus**

Plan on winning more jobs when using Meta-Lax because your production time for stress relief will be at least 8 times faster and completely predictable.

See Article About  
**Corrosion  
Engineering**  
Appendix B.

**Customer Comment:**

*"Meta-lax lets us stress  
relieve an entire die assembly  
as a single unit."*

**ITT Automotive**

## Solving the Treatment Distortion Problem

There is a false concept that teaches that stress relief causes treatment distortion. This belief has become popular only because of the widespread use of "heat" to stress relieve parts. Meta-Lax stress relief proves this concept is false. Meta-Lax is a non-destructive, non-thermal stress relief process that can be used on metal parts without concern for treatment distortion. **The fact that Meta-Lax processing does not cause treatment distortion has become a nice advantage for companies that want to achieve even higher precision machining than ever before.** Meta-Lax processing has been applied on numerous parts that would have been difficult or impossible for thermal stress relief, such as hardened shafts that were within .0005-inch from finished size, assembled die sets, completely finished parts for race engines, and even on assembled engines.



*No fear regarding treatment  
distortion.*

**Parker Boring**

### **Treatment Distortion Bonus**

Plan on achieving higher quality when using Meta-Lax stress relief because you can apply Meta-Lax much later in the manufacturing process.

See Article About  
**Automotive  
Specialties**  
Appendix C.

*"[Meta-Lax] improves the inconsistencies of the previous resonant-vibration technology by using more efficient, more consistent 'subharmonic' vibrational energy, which is optimum vibration stress-relief frequency<sup>12</sup>."*

**U.S. Dept. of Energy**



Research setup for testing.  
**U.S. Dept. of Energy**

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

## Other Stress Relief Processes

Besides Meta-Lax, other stress relieving processes were mentioned earlier. However, each of these processes has very limited application capability. Therefore they are not a practical alternative to thermal stress relief except within their limited capability. A brief summary of each process is given below.

### Natural Aging (or Seasoning)

Natural aging was the common practice before thermal stress relieving. Parts were kept idle for 6-24 months at which time manufacturing continued. Manufacturers today do not want to tie up their inventory as well as add up to two years to their production time.

### Cryogenics

Cryogenics is the "deep freeze" process. The processing requires parts to be placed in a tank and taken to a temperature down to as low as -300-F, then raised in temperature to around +300-F<sup>5</sup>. The process is slow, expensive, and very limited in size (around 6-feet or less).

### Stretch

The stretch method "pulls" the part 1.5-3% of its dimension and release<sup>6</sup>. The parts to be stretched must be simple shaped and fairly small in thickness.

### Compression

The compression method "squeezes" the metal part 1-6% of its thickness and releases. Parts must be symmetrical and usually over 5-inches thick<sup>7</sup>.

### Peening

Peening (or blasting), using steel shot, is used to apply a compressive stress on the surface thereby overcoming the tension stress at the surface<sup>8</sup>. The goal is to improve fatigue life of the peened part. The part must have all of its joints and surfaces easily accessible. Peening is slow and requires specialized personnel. Peening is limited based on the size and weight capacity of the blasting facility and workpiece configuration.

## Other VSR Processes

To avoid any surprise and confusion, it may be worthwhile to mention that other companies have attempted to use "resonant" vibrations to relieve stress. The resonant vsr approach has always resulted in inconsistent performance and at times has damaged the treated workpiece<sup>9,10,11</sup>. Furthermore, resonant vsr cannot be used "during welding." Bonal holds the patent for using "sub-harmonic" vibratory energy to relieve stress in metal. **In sharp contrast to other vsr processes, the Meta-Lax sub-harmonic method, a non-destructive process, is as consistent as thermal stress relief and can be used during welding to prevent weld distortion and cracking.** Currently Bonal has not licensed or authorized any other vsr equipment manufacturer to promote its sub-harmonic technology.



### Customer Comments:

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

**NASA**



*Meta-Lax® Stress Relief –  
The New Standard*

**NASA**

See Article About  
**NASA**  
**Langley**  
Appendix E.

## Conclusion

Meta-Lax stress relief is an effective and consistent alternative to thermal stress relief. **The common problems associated with thermal stress relieving of cost, time, and treatment distortion are not problems with Meta-Lax.** There are no size or weight limitations. There are no negative side effects to Meta-Lax processing which means it can be used much later in manufacturing to achieve ultra high precision machining and grinding. Meta-Lax stress relief has been credited in helping to eliminate high scrap rates on very intricate parts as well as helping set new quality standards in many of the highest quality parts in the world including deep space telescopes. Meta-Lax technology is currently being relied on daily in such places such as NASA, Northrop-Grumman, Boeing, US Army and Navy, General Motors, and countless other quality conscience organizations, from one man shops to Fortune 500 companies.

The bottom line is – Meta-Lax overcomes the cost, time, and treatment distortion problems commonly associated with thermal stress relief.

It's time to let Meta-Lax stress relief work for you.

Contact Bonal Technologies Inc. at 1-800-META-LAX or at [info@Bonal.com](mailto:info@Bonal.com).

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## Appendix:

- A. U.S. Army
- B. Corrosion Engineering
- C. Automotive Specialties
- D. U.S. Department of Energy, Tech Brief
- E. NASA

# META-LAX<sup>®</sup>

# 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



### Reduced scrape rate from 50% to 0.

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."

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.

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

# META-LAX<sup>®</sup> FACTS

Corrosion Engineering

Volume 6, No. 1

## Mining Manufacturer Eliminates Cracking

There are few industries more abusive on metal parts than the mining industry. However, thanks to Meta-Lax stress relieving, **Corrosion Engineering** has eliminated a majority of cracking and fatigue problems on their products.

Located in Mesa, Arizona, Corrosion Engineering specializes in manufacturing Vibrating Screen Decks and Reinforced Feeder Boxes.

These products are constantly subjected to tremendous impact stress when heavy rocks are dropped onto them. As a result, weld strength is put to the test virtually every day. When cracks begin forming, the frequency of repairs increase.

Corrosion Engineering realizes the demands placed on their products and thrives in meeting the challenge. According

to President Don Dunn, "The quality of our products is always a high priority.

That's why stress relieving has been an important part of our manufacturing."

distortion."

Corrosion Engineering switched to using Meta-Lax stress relief equipment in 1991. Since then, Meta-Lax has been applied to the 18-24 cross tubes per Vibrating Screen Deck after fabrication and before machining, requiring only about 30 minutes per cross tube.

"With Meta-Lax, there's no treatment distortion, and we can do more parts. Some parts we can do a second time after machining if we want," Explained Kelly.

Besides saving time and money, Kelly is most excited about the performance of their parts.

**"Since using Meta-Lax, we eliminated cracking in the last 600-700 cross tubes we made over a four-year period. That's unheard of in our business!"**

"With Meta-Lax we save time and money. Since using Meta-Lax, our customers have reduced their maintenance costs since our parts are lasting longer," Kelly added.



*Corrosion Engineering uses Meta-Lax to stress relieve these cross-tubes saving approximately \$70,000 over thermal stress relief.*

In fact, each major component of the Vibrating Screen Deck is stress relieved as well as the entire Re-enforced Feeder Box, which is a weldment.

Prior to using Meta-Lax, furnace stress relief was used. According to manufacturing engineer Jim Kelly, "It would cost

\$2,000 per 20 cross tubes for stress relieving. We also had treatment

**"With Meta-Lax, there's no treatment distortion, and we can do more parts."**



# META-LAX® Application Focus

High Performance Racing Industry

## Automotive Specialists Takes the Checkered Flag **Again** with Meta-Lax®

### Challenge

"In order to build more engines you can advertise all you want but if you don't win races the customers will go somewhere else," said Keith Dorton, president of Automotive Specialists Racing Engines. Automotive Specialists is a small family business which for more than 40 years has specialized in building successful racing engines for the oval track racing circuit including NASCAR and short track circuits. The company wanted to take the manufacturing of their already successful engines to a new quality standard in both performance and longevity.

Due to the brutal demands of the engines during a race fatigue failures on engine parts like blocks and heads, crankshafts, connecting rods, valves and valve springs, oil pans and exhaust headers can be a serious problem and Automotive Specialists wanted to extend the life of these parts. They also wanted to limit the number of engine rebuilds since the rebuilding process sometimes causes a substantial amount of distortion.

### Solution

To help Automotive Specialists address their challenge a manufacturer's representative referred them to Bonal Technologies, Inc. more than 20 years ago. The manufacturer's rep introduced them to Bonal's Meta-Lax® process as a way to help improve the performance and longevity

of their engine components. Meta-Lax, the rep explained, stress relieved metal by relaxing residual stress using a patented vibration energy process.

When they first looked at the technology, Automotive Specialists

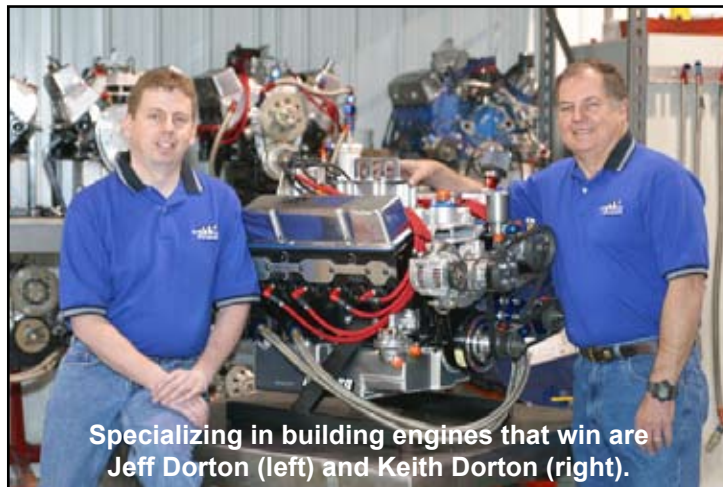
***"Using the Meta-Lax system has improved the overall success of our customers."***

was skeptical since the results touted by Bonal seemed unrealistic.

"I decided to go into it with an open

"In our business sometimes we have to take an existing part and reconfigure it, which requires a significant amount of welding. By using Meta-Lax during welding, we have less distortion and fewer dimensional changes," said Dorton. "Before, we were having a substantial amount of distortion and cracking from the heat of the welding. In some cases the part would have to be replaced."

When Automotive Specialists first purchased Meta-Lax, half of the Meta-Lax system's work was on this type of reconfigure application since they needed to modify production components for racing use. Over the past few years, the industry has changed and there isn't as much of a need to reconfigure these parts. Now the industry has evolved into making parts where they can be used in a high performance engine direct from the manufacturer.



Specializing in building engines that win are Jeff Dorton (left) and Keith Dorton (right).

mind since we had a goal and needed help to achieve it," said Dorton. "After a three-month study, we determined it was worthwhile to use Meta-Lax."

After this trial period, the company felt that the Meta-Lax system definitely provided answers to the challenges they were facing.

Automotive Specialists also found an additional valuable use for Meta-Lax and that was using Meta-Lax while welding on certain parts.

### Details

Engine builders can relate to Meta-Lax stress relief as an "accelerated seasoning"

process. Meta-Lax takes only about 30-60 minutes to achieve what nature would need 1-2 years to do. From either process the result is a stable, crack resistant engine component.

The Meta-Lax process vibrates a workpiece at its sub-harmonic energy level. The sub-harmonic zone is the optimum zone when using vibration. All metal structures exhibit harmonic and non-harmonic behavior. A metal component that contains thermal stress displays its harmonic curve as



being out of phase from its natural frequency location, much like a musical instrument being out of tune. By applying sub-harmonic vibrational energy, the pockets of high stress concentrations are redistributed, thereby reducing the effects of thermal residual stress. Graphically, the harmonic curve shifts slightly but stabilizes into its natural frequency as the workpiece becomes relieved of thermal stress.

The Meta-Lax system can be used with all types of materials such as low and medium carbon steel, tool steel, aluminum, stainless steel, cast iron and exotic metals like titanium, inconel, and stellite, which makes Meta-Lax ideal for valves and valve springs. This process is also effective on parts that have been hardened without any fear of affecting the hardness or causing distortion, which makes it a real benefit for many engine components like cranks and cams.

Meta-Lax Weld Conditioning is applying the Meta-Lax stress relief process during welding. Weld conditioning relieves thermal stress as it is being induced during weld solidification. Metallurgically, a finer, more uniform weld grain results. Ductility and impact values are significantly higher, up to 400% and 75% respectively, which contribute to a dramatically increased fatigue life for those Meta-Lax weld conditioned parts. Additionally, Meta-Lax weld conditioning can prevent up to 90% of the normal weld distortion.

**Result -** "Overall, the Meta-Lax system has made our engines perform more consistent and longer than ever before," said Dorton. "The Meta-Lax system has certainly contributed to our reputation within the industry making it even stronger and more influential. That's because over the past 20 years, using the Meta-Lax system has improved the overall success of our customers."

Automotive Specialists has found that

Meta-Lax provides increased longevity on many critical engine parts. Since there is less distortion when Automotive Specialists use the Meta-Lax, they now have less labor allocated to rebuilds.

Automotive Specialists' customers have won races around the country – from

Daytona to local dirt tracks. The numerous championships include Clay Rogers who won the 2006 Hooters ProCup Championship.

In the 10 years of the Hooters Division, Automotive Specialists has



Two hours of Meta-Lax stress relief saves four hours of extra machining time. Engine block is Meta-Lax treated before final machining.

won 10 Engine Builder of the Year Awards and supplied engines to eight of the championship winners.

When Automotive Specialists used the Meta-Lax system during welding to reconfigure the part they found they could avoid many of the distortion problems associated with welding on high quality automotive parts. This led to less part replacement. Automotive Specialists has lessened weld distortion by 15-20 percent.

***"The Meta-Lax system has made our engines perform more consistent and longer than ever before."***

Another benefit found with Meta-Lax processing is quality assurance to prevent additional rework down the line. "If we spend two hours up front when we're building the engines to stress relieve various engine parts, it saves us four hours of machining

on the rebuilds," said Dorton. "Overall it has been good for our business efficiency to use Meta-Lax."

Financially, Automotive Specialists has benefited because of the quality product that they have provided to customers. Since the company provides a sound and reliable product, Automotive Specialists adds a fair price to the cost of the product for the Meta-Lax process. This provides a source of income for them because they already own the Meta-Lax system.

"Meta-Lax is a versatile system that we recommend to other companies" said Dorton. "I'm sure that many other industries could also benefit from using this technology."

The Meta-Lax equipment has withstood its 20 years at Automotive Specialists very well. The system is used several times per week. According to Automotive Specialists, the system has been virtually trouble free.

In 2000, Automotive Specialists was contacted by the U.S. Department of Energy to conduct research on building a more efficient engine. This goes hand in hand with what they do for the racing industry. Instead of emphasizing power, speed and longevity, for the DOE they use their knowledge of building high performance engines and with Meta-Lax to emphasize fuel efficiency, emissions and economy. Since 2000 they have worked on a number of projects for the DOE.

# METAL CASTING

## Success Story

### META-LAX<sup>®</sup> 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

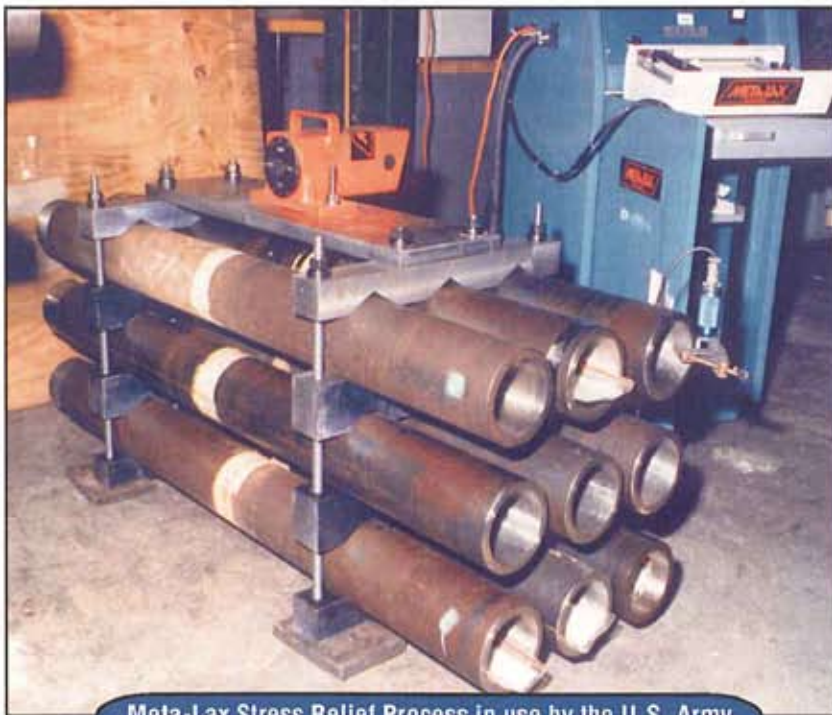
Metal fabrication and machining industries; applicable to castings, forgings, weldments, and metal plates.

"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





## 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<sup>®</sup> 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.

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.

"Since we began using Meta-Lax, we have experienced the ability to hold dimensional tolerances on weldments



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

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."

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