Truth Compassion Tenacity

These are the foundations on which I try to live.

As I advanced into my 80s, I wish to document many random thoughts that I have written over 65 years. The hope is that the readers may glean some benefit. In order to make it a little easier to deal with, I have separated them into different categories. Initially the categories will be rather broad, but I hope to have clear subcategories.

The categories will be:

Technical observations:

Ignition:

Fueling:

Welding:

Opinions:

Proven facts:

Technical observations:

There is a tendency to use words that sound like one has knowledge of what they mean. Often, they don’t have a damn

clue. The commonly misunderstood word, detonation, has been used as a catchall for any engine combustion problems. True detonation will have a given propagation rate for the substance involved. There are many other buzz words that the uninformed use to make themselves seem knowledgeable. The Internet has spawned thousands of experts that know everything. These so-called experts generally offer half assed opinions on every side of every issue. Choose your sources of information carefully!

Our current project is the measurement, and documentation of high speed pressure waves. We have documented pressure waves and forms at a very high speed. We not only can see the pressure waves, we can see the shape of the pressure waves. We have a great deal more work to do in order to gain more understanding. This is hard, time-consuming, research. But we have achieved repeatable documented waveforms and pressures.

One of the older projects is destructive detonation caused by over fueling, and over temping the stratified charge of either methanol or nitromethane is stratified charge in the cylinder. We have documented cylinder pressure every quarter of a degree. The project went on hold due to medical issues. The ultimate goal was to drive an engine to destructive detonation while instrumented. Below is a little bit of information of what I have observed, and the chronology of events that led me to my theory of destructive detonation.

A customer blew up another engine just off the dyno, they said too lean, bullshit! The engine had the same failure pattern of their last year 2 lap blow ups. 6 of the 8 pistons show NO heat and look very rich, while the one that failed first shows massive heat and the piston dome was extruded down .400 over the pin, exhibiting classic black death symptoms; and as a result, broke a very high dollar connecting rod. All of this in 2 laps, in an engine that ran well on the Dyno. With that level of destruction, I set out to find a reason why that would occur.

Upon inspection of the car cooling system I found the problems: A: a surge can with a standard radiator 22 psi filler cap was plumbed into the suction of the water pump, thereby facilitating the introduction of air into the system through the vacumn break valve in the radiator cap. As soon as the pump started to pump water the suction goes negative and it pulls air into the system.

B: A much larger crank driven water pump pump, that was too large for the system was utilized and it would pull 19" HG on the suction at 6500 rpm. This would cause water to boil at 99F and there by steam bind the pump.

C: The radiator was mounted in the horizontal position It was a double pass unit, 20Wx18T 2 row FX style core. So the effective tube area was the same as if the radiator 10" W x 36 T; the Radiator did not have sufficient flow capacity to prevent the large pump from running the suction into a large negative suction pressure which caused the suction water to flash into steam thereby stopping all circulation.

TEST: To verify: We placed the engine on the dyno with all race car plumbing and radiator, and ran a test. It pulled 19" HG negative on suction, pulled colored water up vent tube proving my theory of air introduction into the running system through the 22 psi pressure cap. We then plugged the vent line in the system. We then ran engine to 6500 and the unit promptly steam bound and circulation stopped

FLOW test used 30 gallon barrell with 1.750" welded into bottom side, 18.5" dia., filled with water and ran engine to purge. With engine at full load 6500 rpm removed all discharge lines from barrell and dumped on floor for a 15 second test run. measured barrel draw down and computed water consumption. results as follows:

large pump, (4) .200 restrictors and (2) .270 #6 90d fittings in center of heads.

6000 rpm = 39 gpm , 6500 rpm = 44.3 gpm

std. pump same restrictors:

6500 rpm = 33.8 gpm   6800 rpm = 37.24 gpm

under these conditions the big water pump generated a9" hg suction depression, and the std. pump generated a 6-7 " hg depression. consulting the altitude v/s boiling temp charts shows that with a 9" hg depression and a 1000' base elevation, water will boil at 151F so it is imperative that the radiator does not cause a delta across the core as this will cause the water to boil off in the pump inlet and vapor lock the cooling system. This is probably what happens to most race car cooling systems, and when circulation is denied, the water in the head near the exhaust ports goes to vapor and it will NOT recover until the engine is shut off.

This led me to the conclusion that the engine in question had no cooling from the water in the area of the destruction. This was due to the suction of the water pump running 19 inches HG, and thereby flashing the water in into steam because of the restriction imposed by the radiator was did not have sufficient flow capacity.

This allowed the material of the cylinder head to achieve what I will call kindling temperature.

Now we move to the meat of the theory.

A: The mixture of fuel and air in the cylinder is not homogeneous. Droplets of fuel may be sequestered in various areas in the combustion chamber.

B: The pressure in the cylinder under compression is controlled by two things; the mechanical position of the piston as it moves on board in the cylinder; and the pressure of the burning mixture.

C: Compressing the mixture introduces heat, which would normally cause the fuel droplets to flash into a vapor, but the upward movement of the piston raises the pressure and keeps some of droplets as liquid. If these droplets are sequestered in an area of the chamber that is near the kindling temperature the increase in pressure by the due movements of the piston and flame front will keep them as liquid until TDC rock over. As TDC rock over the mechanical component of the Pistons the upward movement is lost. I wanted to degrees after child dead center it now reduces the mechanical compression and the sequestered droplets now blasts out into an existing flame front without the fuel droplets exfoliating on the surface of the droplet as they would normally do.

I theorize that the collision of those to flame fronts cause an abnormally high pressure when the rod is essentially toggled and cannot move downward. The broken examples of the piston extruding over the wristband and less than 35 seconds at full load on the racetrack with no adequate cooling supports this.

The reason is that not show up on the Dyno is they did not use a compromised cooling system. The failure sequence did not occur when we removed the inlet restriction, and use a smaller water pump and a larger single pass radiator.

I have some evidence in physical parts, and some evidence in pressure per degree in the combustion chamber.

I will add more to this later.

2/22/2011 this is a copy of an insight that I had in 1990 on the destructive detonation (true detonation) this is the beginning of my thoughts.

Key words: detonation . exfoliation , superheat , Nitro , fuel burning in pipes , xxx called to say they blew up 2 engines in Florida last week. He thought the air was so good 800' below sea level, too much compression 16 to 1, to much timing 32 deg. too much fuel ..... etc. He said 1 piston was just gone. Just a wrist pin left. I asked how the other holes looked, he said perfect. I told him this was a complete repeat of xxx engine that I have the piston and broken rod here that helped me refine my theory on superheated fuel , kindling temperature , phase conversion , rapid pressure rise 1 to 3 degrees ATDC , cylinder pressure , Jay Gordon helped me and wrote the algorithm to allow me to take data in time @ 386 megahertz and convert it to show cylinder psi in crank degrees.

Below are some of the previous notes:

Engine theory as the piston rises the increase in pressure offsets the increase in temperature and holds some of the methanol in liquid form, when the piston rocks over TDC the increase in pressure is now aided only by the advancing flame front and as the piston moves downward the resultant momentary decrease in pressure and the removal of the quench effect may allow the droplet of methanol to burst into

vapor and confront the existing flame front thereby allowing extremely rapid initiation of a second flame front. This is probably why engine with extremely high compression experience destructive detonation when they are run a little rich. 11-15-90 approx. date of this insight."

My thoughts as of 5/30/00. Whenever there is anything that the fog of fuel can hit such as a dam between the valves or a spark plug side electrode, the fuel re coalesces or my term re-globalizes into larger fuel balls. When that fuel forms globules it causes another area of the chamber to see a leaner mixture and less mist cooling. If there are fuel balls or globules present then it is a certainty that another area of the charge is fuel deficient. The unevenness of the fuel mixture causes a stratification in the time line of combustion events. Whenever there is a change in phase of a liquid to a saturated vapor the time balance and heat transfer/ absorption rate changes.

Any time there is an unbalance in the mixture distribution in the combustion chamber, there will exist an unequal time frame for the combustion propagation. MY long-held theory of fuel globules being held as a superheated liquid and then exploding into an established flame front when the piston rocks over TDC is being supported by these observed changes and the benefits reaped.

Spring of 1961, tuning road race motorcycles and trying to understand the effect of open megaphones versus reverse cone megaphones on the engine power curve. In the background on AM radio was the 31 song “Barbara Ann” by the Regents. The tag line of the song; Baa, baa, baa, Barbbarbra Ann, stuck in my mind for the last 40 years because that sound approximates the sound of an engine in

a reversion induced stumble.

A reversion induced stumble is a condition in which an engine will not accelerate cleanly when the throttle is opened. The resultant series of incomplete combustion sequences give the engine a sound much like the song "Barbara Ann", hence I named this condition the "Barbara Ann Syndrome" An engine in strong low RPM reversion will misfire, stumble, burp, and there is little the driver can do to improve the situation. You have experienced a classic manifestation of the "Barbara Ann" syndrome when your car stumbles when you pick up the throttle in the middle of a slow corner and the engine won't do anything for about 2 seconds except stumble and burp regardless of how you move the throttle (Baa, baa, baa), then in an instant the engine clears out and blows the tires off the car (Barbbarbra Ann). The problem occurs in the middle of a slow corner, usually after about 8-10 laps when the engine is hot and the track is grippy. If the driver can spin the wheels the problem is unlikely to occur, often misleading the tuner into believing the problem has disappeared.

In the last 12 years I have spent an inordinate amount of time in the investigation of the strong low speed reversion pulse using high speed pressure transducers, mass air flow sensors, and video recording. As a result of this work we have been able to reduce the effects of the strong low speed reversion pulse and in most cases modify the engines response in such a way as to circumvent the problem in a given set of race track conditions. There are significant differences in effect, between a strong low RPM reversion, and a weak higher frequency high RPM reversion. I will confine our focus to the strong low RPM reversion pulse that causes the "Barbara Ann syndrome".

An engine reversion cycle has compromised the ignitable fuel / air mixture available at the spark plug. In many cases the misfiring is mistakenly attributed to the ignition or fuel system. It is natural to blame the fuel or ignition systems when the engine is misfiring, but the root cause of the problem is much more complicated.

Reversion takes place when a moving fluid loses directional inertia and reverses the direction of flow, usually for a small fragment of the normal flow cycle. Reversion is a condition that may propagate its cycle throughout the entire gas tract of a running engine. It has been helpful to study both 2 cycle and 4 cycle engines to gain a better understanding of the causes and solutions to reversion. The largest gains in engine tractability have come though understanding how to harness the power of wave reflection to help volumetric efficiency. A generalization may be made that when wave reflection is optimized to give the best volumetric efficiency at any given RPM the performance at other points in the RPM range may suffer. This is particularly true when the reversion phenomenon manifests itself.

During the intake cycle the fuel / air mixture uses its induced inertia to fill the cylinder. If a reversion wave is propagated the air loses its inertia faster than the fuel droplets causing a different fuel / air to be presented to the ignition source. If the fuel / air mixture was correct before the onset of reversion, it most likely will not be correct during the reversion event.

The strong low RPM reversion pulse of the “Barbara Ann syndrome” causes the most significant disruption to constant flow IR fuel injected engines, but it will cause similar effects in almost all types of induction systems. The low RPM reversion pulse is by definition, RPM related and is a function of wave reflection and/or low gas velocity.

Recognition of the conditions that promote a strong low

RPM reversion pulse allows us to suggest some generally effective tools to manage the problem.

Social observations, opinions, of which there can be no proven facts.

Of all the things that I have said the one that means the most was in response to your question about that Karen asked me in about 1978. She asked me what I thought was important, I thought about it for a couple of minutes and answered her. "Truth, compassion, and tenacity." My reasoning was as follows: without truth there is nothing, if you are truthful there is no better use for the truth than to have compassion, and if you are truthful and compassionate you better be tenacious.

About 1972 I said "failure is my friend" the reason for that is only through trying and failure and trying again, will you learn perseverance. Easy success tends to make you overconfident.

"Most people prefer a pleasant lie, to a brutal truth" I want, and try to speak the brutal truth.

12/24/2020

"a good lie, beats a brutal truth, every time ; In The Short Term ."

"Facts require proof, opinions do not."

“Men use money and power to get sex, women use sex to gain money and power”

I made this observation in about 1975

“Thinking is relatively easy, putting the thoughts into action is harder. Only by doing something productive with your thoughts does thinking come to fruition.”

“When men get their feelings hurt they get mad. When women get their feelings hurt, they plot, and get “even”.”

When I was about 23 or four years old I wrote: “should’ve, would’ve, could’ve, the three vagrant sisters of despair”

5/14/2021 In almost every situation, perception is in conflict with reality.

Explanation: if a person believes in what he perceives, for him, it is reality. That does not make it reality in the absolute sense, or in another persons perception. A person’s perception may also be called belief. Reality is what is conditions of anything at that moment.

***6/5/2006 In conv. with Karen I stated that people are ruled by either guilt or shame.**

Guilt can be kept internal and is easier to self manage. This allows further damage to self image.

Shame is when one's actions become known. Outwardly this causes more distress than Guilt, but the action of exposing the guilt and transposing it into shame allows the healing process to begin. Shame forces acknowle1gment of poor behavior and allows us to begin a process rebuilding self

esteem through corrective action.

It has become clear to me that my mind functions better in an analog type reference. use a clock as an analogy. a quick glance will give you information without trying to resolve numbers.

*** 6/1/04 " I don't unload my ego along with my race car." i can get just as broken as a race car.**

***6/1/04 My life is determined by "Why" as opposed to "what"**

2/24/01 12:18PM my quote: " Good looking young women are " Self propelled trouble machines."

4/22/99 I was watching a program on the learning channel about children learning to lie and some thoughts came to mind.

Most adults lie to gain temporary power over the person they lie to.

I believe that if I lie I lose power over my own life. No one who has a conscience can lie wtihout psychic pain. Freedom from the devils of ones own conscience can only come from the courage to live the truth.

7/15/97 Ivan Sams told me of an old doctor who was a family friend when his family lived in Senegal. The quotation that the old doctor gave him to explain how people with different levels of material possesions can seem to be equally happy or unhappy is: "Life is an equality under the appearance of

inequality".

Ivan on discussing his MIG 21 flame out and subsequent dead stick crash landing in a small field and woods: He told his parents later that he did would not want anyone to say " He died happy because he was doing what he loved." Ivan said that he was decidely NOT happy with the events leading up to his crash landing, and that dying in a plane crash is not how he wants to go.

7/3/97 12:40PM Call from Ivan Sams; told me of landing a MIG21 in a field 1/2 th e size of where he landed the AT-6. Told me of a old Doctor in Senegal who taught him about life.

Flew planes for Niki Lauda and drove one of his ex F1 cars at his private track.

Autobiographical information

I want to write the history of RaceSaver. I'm going to call it RaceSaver the peasant's revenge.

It all started in 1996 I believe when Mike Williams called me about starting an economical Sprint car class. We had a good conversation and I told him I would help and he had the other principle Bill rice call me in our conversation wasn't as smooth. Bill called Mike back and said: "don't ever call that son of a bitch again." Now 27 years later Bill and I are good friends and Mike has moved out of the Sprint car world. There were just three of us in the beginning, Mike and Marianne Williams, Marianne being the driver, Bill rice owner and driver, and myself. Within the first couple of

demonstration races we realize we needed some rules so I set about writing them. Jim Haines came to our first race to help me out and is been there ever since at every race. My first contact was JV Brotherton of Brodix cylinder heads. We had known each other are quite a while and I asked him if he can make a cylinder head and sell it only as a RaceSaver head. Without JV Brotherton's help and support there would be no RaceSaver. Our agreement was such that every had would be measured and recorded by serial number so we go and tell the history of that head. We were committed to making sure all the heads we sold were the same. And nobody would guarantee that except for the very courageous JV Brotherton.

With that as a beginning I set about writing the rules. And when I had written the rules, I sent them to many people in the industry for their opinion and how they were to cheat the rules up. Many said it would never work. The rules have not been substantially changed and 27 years. The only thing we have done is to explain what no means. You can print no in capital letters and bold type, and it don't mean a damn thing to the racer looking for an advantage. So foolishly ever hopeful I said the head can have no changes to it. Boy did I have a lot to learn. I had to spell out every possible thing that could be done the head and say you cannot do it. All the other rules had to go through the same excruciating process. Within the first three or four months I probably had what NO meant fairly nailed down. The whole idea of RaceSaver rules was to allow innovation within financial sustainability limits.

As we grew a little bit, we attracted the attention of some very notable people. Tom Worrick in Pennsylvania, Rod Ort also Pennsylvania, and Joe Grandinetti. With these people supporting RaceSaver® we began to grow. The next major player was Smiley Sitton of Texas. And finally through divine

intervention Roger Hadon and I got together. I sold Race Saver® to Roger for one dollar because he had the same commitment to the principles Race Saver®. Jim Haines has been my constant companion, and sounding board for everything that we have accomplished in RaceSaver®. Is a member of my family. He can remember almost everything that is ever happened as we grew. Together, we have accomplished more than we ever dreamed.

We will add more to this as time permits.

As technology has increased, the amount of money but to be thrown at a problem, has increased exponentially. Money and power are joined at the hip. In those 1970s I made the observation that "men use money and power to get sex, and women use sex to gain money and power."fhg1975

racing is a prime example of money stifling independent thinking. Many think but they can just buy their way into winning.

Rx for Sprint Car racing & open wheel racing

2003 found Sprint car racing in a confused state. The Knoxville Nationals, Eldora's Mopar Million, Steve Lewis IRP Midget show (name needed) all paid huge purses to the already rich and famous. What could possibly be wrong with that scenario? Simple; Cannibalism, Our sport is eating its young. Regular Saturday night shows that are the backbone

of short track racing are struggling.

How did we get to such a sorry state, and who is the villain? The answer is both simple and blasphemous: Television and too much sponsor driven spending. Racing skills have become secondary to the " sponsor friendly package". Television and ego seduced us with visions of fame and fortune. Lost in the mad rush become the new PC speak racer, we forgot why we race. Racing is about the journey, trying and learning so we might be become better racers. If the only people who raced, were the unnaturally talented drivers destined for fame, there would not be any local racers, local fans, or family & friends to support them.

In retrospect the strengths and weaknesses seem obvious.

Short track racings strength is the reality of sounds, smells, and a full visual panorama of a real live race. Television fans never experience a physical connection with the drivers and cars. The fans in the stands are the family and friends of the guy running 12th in the feature. They care; and this inspires good racers to race better.

Television focuses on the cars up front. This is great for promoting national level stars and sponsors; but lousy for normal drivers and car owners trying to become the next Ryan Newman and Roger Penske. Good drivers

raced hard and failed to beat the stars. Semi wealthy team owners went bankrupt financing the path to stardom. Engine builders, car builders and parts manufacturers hoped that television exposure would bring enough business in the door to cover the free parts deals. We were spending money like a drunken sailor.

7/28/09 And, while we are naming TV and spending as culprits, we had better get some windex for our mirror and take a good clear look at ourselves. If you think the average short track is rolling in money you are delusional. If your

track has many classes and low car counts, where do you think the promoter is going to get the money to increase the purse. I recently was at a track that had 11 classes scheduled for the evening. They were one hour late starting, and were up against a tight curfew. Why is this happening?

Since money and television are constantly mentioned as the keys to our sport succeeding; let us look at what they cannot provide. Good competitive racing! Money increases the gap between the haves' and the have nots.

What do we spend money on? More power, lighter weight, more down force, stickier tires, trick electronics, traction control, and a much bigger hauler. Every damn thing I just listed works against better racing.

The only thing that any of this changes is the cost to be competitive. Most racers want to buy an advantage instead of having to think and work. Once an advantage can be bought it just raises the cost to compete. Look at the traction control mess. If you think you need it to compete; then pony up $6500 for less than $100 worth of electronics. Once everybody has it then you are even again, but $6500 poorer. A field of 24 cars will spend $156,000 for everybody to get on an even playing field using traction control. But let's not just pick on traction control. The use of technology in short track racing has run amok. Because rule makers are usually behind the curve on understanding trends, a few wealthy and technologically aware racers can introduce concepts borrowed from Formula One or Nascar. By the time the rules makers catch up the technology is well established and difficult to outlaw.

3/2/04 In March of this year Bobby Unser appeared on Dave Despains' Wind Tunnel. Unser made the point that technology is the culprit in removing drivers as heroes from

the spectators. He made it clear that spectators come to see drivers make spectacular skillful moves on the track. He cites Sam Hornish pass of Helio CastroNeves at Homestead as an example of what he calls the best passing move he has seen. Unser also makes the point that a real driver's championship would include midgets, sprints, silver Crown cars as well as IRL type cars. This would require more driver versatility. Kasey Kahne, Ryan Newman, Stewart, Jeff Gordon, all came from this varied background.

The real culprits in technology are electronics and aero. Both require huge amounts of money in order to gain an advantage and therefore limit their benefit to the most well financed and technology capable teams.

Ignition:

There are two types of ignition currently in use in race engines, spark ignition and compression ignition. Unfortunately when a spark ignited engine malfunctions it may ignite prematurely from compression ignition. This is commonly referred to as pre-ignition, and is usually very destructive. While the engine may survive numerous cycles of light detonation, they usually cannot survive many cycles of pre-ignition brought on by a spark ignited engine going into compression ignition. Sometimes in Nitro dragsters and funny cars the spark plug may melt the electrode and act like

The amount of ignition energy required is directly related to the fuel being used. Gasoline is very easy to light with a spark. Nitromethane is very difficult and requires a lot of ignition energy. Methanol is somewhere in between gasoline

and nitromethane. I facetiously say that you can light gasoline with a damp match because it is not sensitive to more spark energy once it is lit. Methanol and nitromethane seemed to respond well to a longer duration spark, and definitely require much stronger spark energy.

Most racing electronic ignition systems use some form of capacitor discharge to supply the energy needed. The spark thus provided is a high intensity, and very short duration. They do well on gasoline fueled engines but not as good on methanol or Nitro engines. In documented tests the CD variant ignitions have one strong pulse. The magneto ignitions would have the same breakdown voltage of anywhere from 16 to 22 kV but then would

continue on after ionizing the gap at about 900 V for a number of milliseconds. This is helpful because methanol and Nitro initiate a flame when they feel like it; not when the timing light goes off.

We will add more to this as time permits.

WELDING:

THE WELDING OF 4130 tubing has in many cases changed little since the

1930s when light aircraft frames were first being fabricated with the then new alloy tubing. In the thirties the correct procedure was to use an oxy-acetylene torch with a neutral flame and a mild steel or a low car-bon filler rod. This accomplished four things:

1. It preheated the tubing reducing the problems of free hydrogen associated with moisture.
2. The preheat reduced the possibility of the metal mass causing quench hardening of the weldment.
3. The larger weld puddle of the oxy-acetylene flame allowed for considerable filler rod to base metal dilution thereby giv-ing reasonably good alloy properties to the weld metal.
4. The high total heat input annealed the tubing near the weld, thereby concentrat-ing any compression or tension failure in this area rather than the weld zone which had air hardened.

The same procedure is still used in light aircraft fabrication and is approved by the F.A.A.

Today we have at our disposal better, al-though technically more complex, proce-

dures. Better welding alloys, G.T.A.W. (Heli-arc) welding equipment and programmable welding power sources can offer more lati-tude in the fabrication of 4130 structures.

In most cases of current race car con-struction the welding procedures are a curi-ous mix of both new and old methods. A small survey showed that the rods most commonly used in 4130 race car construc-tion are Oxweld 1 or Linde 65 using a Heli-arc welding process.

In order to ascertain if this process could be improved, a test program was planned allowing testing of different rods for tensile strength and ductility.

Tensile strength alone is not the best cri-terion for selecting a filler metal because race cars crash. When a car is crashing, en-ergy must be absorbed or transferred through the chassis and roll cage. If a weld material has high tensile strength but low ductility, then a joint either breaks or trans-fers all of the energy applied to it.

If a weld material with a medium tensile strength and high ductility is used, the weld metal can yield when energy is applied and in so doing absorb some of the stress with-out failing completely, or transferring all of the energy to another joint. When a partial failure of a triangulated joint occurs, it puts the intersecting members in bending as

well as tension and compression. The bend-ing of the members absorbs more energy as the joint fails. In order to allow the joint members to fail in this manner, the weld joint needs to have a large range of plastic deformation or ductility before weld failure.

In order to find which rods and proce-dures would give the best combination of tensile strength and ductility a number of tests were conducted using different weld-ing rods with the same procedure. The re-sults were compiled and the tests repeated changing only the procedures. Over 150 test welds were made with 100 tests being confined to sized test samples. The welding rods tested were:

1. Oxweld 1
2. Linde 65
3. Eutectic 66
4. Eutectic 680
5. Reid-Avery 4130
6. Reid-Avery 517 G
7. Rein-Avery 312 stainless
8. Reid-Avery 310 stainless
9. McKay 309 stainless
10. McKay 908 stainless
11. McKay 316 stainless

The basic welding process was G.T.A.W. (gas tungsten arc welding, commonly known as Heliarc) using argon shielding

(above) The author, **French Grimes,** called an impressive number of builders of race cars, plugged in his own experience and then asked some of the most qualified welding engineers how to do it.

Tensile strength alone is not the best criterion for selecting a filler metal! because race cars crash.

gas with variations in preheat, metal thick-ness, argon backup shielding, and joint restraint.

Test samples were also welded with an oxy-acetylene torch and the results

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indi-cated that this procedure supported

the earlier mentioned arguments for its early use.

The test procedures were: 4130 plate was formed into 90° angle strips and cut in 3 1/2" lengths yielding test samples 3 1/2" L x 1" x 1" x .120 or .187. The ends of the samples were ground to a single vee edge to assure good penetration and were welded from one side. The test material was designed to cause failure in the weld zone.

Normally the welded joint will not fail in the weld zone in bending load if the same cross-sectional area is maintained. This is because the area adjacent to the weld was heated sufficiently to anneal the base metal while the immedi-ate weld zone was heated to a higher tem-perature allowing the metal to air harden after welding heat was removed. Some-times in actual practice the area next to the weld will strain harden as it deforms and will then transfer the ultimate failure back to the weld zone.

After welding, the lower section of each sample was secured in a vise, a recording memory torque wrench, with a special adaptor and an inclinometer, was attached to the upper section. The samples were then bent until failure, with the root of the weld being placed in tension. Recorded re-sults were: angle of bend at maximum strength; angle of bend at failure; maxi-mum strength.

Variations in procedure included:

A. argon backup and current pulsation welding with no preheat
B. with preheat, current pulsation and ar-gon gas backup shielding (predominant procedure)
C. restrained joint tests
D. oxy-acetylene welding
E. high and low dilution techniques

The summary of the test averages show four rod types that typify the many tested. Linde 65 is used to cover Oxweld 1, Eutectic 65, whose test results were similar. Reid-Avery 517 G covers 4130 also. The two stain-less alloys 312 and 309 cover 308 stainless, 310 stainless, 316 stainless, and 680 Eu-. tectic.

While all of the rods have similarities to their group in the test results, the rods shown in the chart were chosen because of specific characteristics that made them su-perior to others in that group. The designa-tions .187 and .120 refer to the thickness of the test samples.

Rod Type Strength	Degree of Bend at Maximum	Degree of Bend at Failure	Foot lbs. Bending Maximum
-inde 65 (.187 thick)	10'	15	46.8
Linde 65 (.120 thick)	15°	20°	24
Oxweld oxy-acty. torch	9.5'	15.7°	19.5
Reid-Avery 517 G (.187 thick)	7.5°	12°	55.8
Reid-Avery 312 (.187 thick)	26'	55.9'	41.8
Reid-Avery 312 (.120 thick)	32	49.7'	27.6
McKay 309 (.187 thick)	30°	75°	44.7
McKay 309 (.120 thick)	45'	87°	24.5

The tests show the steel alloy and mild steel rods to have high strength but very low ductility.

A mild steel rod might be assumed to have better ductility than the results show, but base metal dilution makes the weld metal higher in alloying elements than the rod was originally, thereby giving the weld-ed joint higher strength and lower ductility.

The stainless rods have a lower tensile strength than the 4130 base metal but when the welded joint is completed the bending strength was usually only 5%-10% lower than the steel rods while giving 500%-700% better ductility.

Changes in welding procedure can also make dramatic differences. As mentioned earlier, most of the tests have been con-ducted with preheat and argon backup shielding. The argon backup can be achieved in actual car construction by fill-ing the tubes with argon while welding is taking place. This backup gas prevents the weld from oxidizing on the back side and promotes weld root integrity. Use of back-up gas seems to improve joint strength marginally. A fixture can be fabricated from a C-clamp to allow the tubing to be filled with argon through a '/16 diameter hole which can be closed later if desired. When using backup gas shielding it is necessary to allow for a gas escape path so that pres-sure will not build up in the structure; such a pressure buildup would be detrimental to weld integrity by causing porosity.

The most critical variable in welding 4130 tubing is preheat. in most cases this very vital step is overlooked or its importance minimized.

The reasons for preheating the weldment are:

1. To decrease the cooling rate of the weld thereby reducing quench hardening. This quench hardening produces high car-

bon martensite which is very hard and brittle.

2. To assist the escape of any free hydro-gen in the weld zone. (The presence of free hydrogen is due to moisture present in the atmosphere and on the metal.) This hydro-gen causes what is commonly known as hydrogen embrittlement and is very de-structive to the weld strength.
3. To allow some tempering effect in the base metal.
4. To reduce the cooling rate of the joint, allowing the welding stresses to distribute themselves over a larger area.

A good example of the need for preheat is shown in this comparison of two weld tests, one with preheat and one without. Note the angle of deformation before failure.

	Degrees at	Degrees at	Foot
Rod	**Maximum**	**Failure**	**Pounds**
no preheat 517 G	2'	2'	55
preheat 517 G	10'	15'	55

The preheating should be done with a torch to a temperature of 200c-400°F. and this temperature should be maintained until the joint is completed.

Since the ratio of ductility to strength is considerably better with the stainless steel filler rods, they offer a better choice in the construction of tubing structures. The test tables show 309 and 312 alloys to be similar in results with variations that can be used to advantage.

The 312 rod has a high ferrite rating. This high ferrite content helps minimize hot short cracking; but when weld puddle dilu-tion increases, the total joint strength and ductility decrease. The 312 alloy would be a good choice and performs best in a situa-tion where little or no preheat is possible, such as tacking up the frame. The resulting reduction in total heat input causes less total weld metal dilution. When there is lit-tle base metal dilution of the weld puddle the 312 rod performs best.

The 309 rod has a higher nickel content than the 312 and has a lower ferrite level but not low enough to cause problems with hot short cracking. When the weld puddle dilution increases, the weld strength tends to increase while ductility remains the high-est of any rod tested. This consistent high ductility and good strength make this rod the best apparent choice of all rods tested for welding 4130 tubing structures that will not be post-weld heat treated. The 517 G or the 4130 rods would be a good choice if post-weld heat treatment was desired. Bear in mind that increases in ultimate tensile strength usually come at the expense of ductility.

To summarize the results of the tests:

A. Preheat is very important if good duc-tility is to be achieved.
B. The mild and alloy steel rods do not give good ductility.
C. 309 stainless is a good choice for a balance of strength and ductility. It gives an ultimate strength within 5%-10% of the strongest of the steel rods while allowing a 500%-700% increase in ductility.

Notes on weldor technique:

A. Do not overheat, as a high rate of base metal dilution is not desirable.
B. The weld bead at a joint intersection, other than butt joints, should have a slightly concave cross-section (not undercut) in order to have a gradual change in cross-sectional area. This will reduce the stress concentration.
C. G.M.A.W. (gas metal arc welding, also known as M.I.G. or wire feed welding) is the least desirable process from a ductility standpoint when used without pre-heat. The heat of welding is very concentrated and the quench effect of the base metal will cause the joint to be very hard and brittle.

D. Stick electrode welding without pre-heat will have approximately the same ef-fect as G.M.A.W, welding.
E. Oxy-acetylene welding with a mild steel rod will yield fair results on thin gauge metal (.049 or thinner) and because of the large heat input it will anneal the surround-ing metal reducing the likelihood of the weld itself failing. This process still does not consistently reach the strength and ductility of the G.T.A.W. (Heliarc) process when using stainless 309 filler rod. The best process is G.T.A.W. (Heliarc) welding with preheat (200°-400°F.) using argon backup shielding as well as argon main gas shielding. The welding rod used is 309 stainless. After welding the argon is al-lowed to flow over the weld bead until the color has left the weld zone.

Any detailed questions on the tests or procedures can be directed to:

French H. Grimes

Madison, Virginia 22722 540-923-4541