A Sure Foundation

Comparing the Jule Frame to the Healey Original

by David Seib, Niagara Frontier Chapter

Four years ago, I visited Jule Enterprises while on business in Canada. As a metallurgical engineer, I wanted to evaluate the structural differences this option offered. Martin Jansen, owner of Jule Enterprises, and I discussed the weaknesses of the original frame and the potential improvements offered by the replacement chassis. Having owned a 100-6 for eighteen years, I have become very aware of the lightweight design of the original frames and the severity of degradation these frames can suffer.

As I would discover, the Jule replacement frame is produced using methods well established by numerous modern day shops specializing in aftermarket frame replacements for street rods. These methods incorporate the use of gas metal arc (MIG) welding and commercially available hollow structural tubing. Many street rod frame manufacturers advertise the use of 1/8 inch wall 2 x 4 inch tubing. The Jule frame uses 1/8 inch wall 3 x 4 inch tubing so as to provide the proper width for the Healey suspension brackets, and same depth of oil pan "protection." For those unfamiliar with structural tubing, it is actually a strip of sheet metal that has been rolled to form the corners, butt welded along one seam, and then pulled through more rolls to achieve straightness.

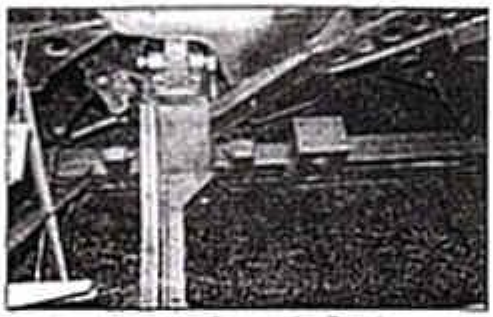
The original Austin-Healey frame was fabricated by welding two 0.072 inch thick "C" channel stampings together to form a box shaped tube. The welding of these stampings was performed using longitudinal edge welds. These edge welds were most likely selected for their significant fabrication advantages, which include: lower tendency to warp, ease of inspection and ability to hide joint misalignment. The fabricated box shaped tubes (i.e. rails) had two flat parallel surfaces on the top surface, with a 3/4 inch height transition at about the rear shock towers. The bottom surfaces of these main frame rails display a constant bow. Maximum tube height, 4 inches, occurs at about the forward outriggers. Tube height at the forward and aft ends of the car are 3 inches and 2 inches respectively.

At this point, I believe it is appropriate to state that some enthusiasts strongly object to seeing a non-original frame under a car. Serious thought should be taken before replacing a frame, as this is expensive and need not be performed twice. My advice is to be confident in structure, brakes and suspension. These items are critical for safe operation of the vehicle. The frame is the foundation of the car.

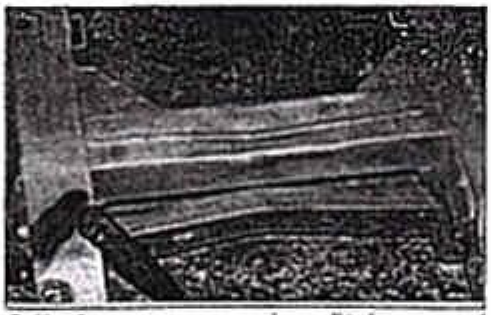
During 1998, Mr. Jansen asked if I would present a quantitative comparison of the original Austin-Healey 100/3000 chassis versus the Jule replacement chassis at the 1999 St. Louis Conclave. As a metallurgical engineer, this sounded interesting, so I accepted. The following is that comparison.

My first step was to perform a search for information about the acceptance tests performed by Donald and Geoffrey Healey regarding the original frames. Pages 40-50 of *The Healey Story* by Geoffrey Healey proved quite valuable. Donald Healey had recognized torsional stiffness contributed to handling and specified that the frame was to have torsional stiffness equivalent to the Nash-Healey N type. He also stated that the frame was to have a maximum allowable frame bending stress. Unfortunately, Geoff did not reveal this maximum stress value. Geoff did state, however, that the torsional test was performed by a method of holding the front shock towers fixed and applying weight to the rear spring hangers.

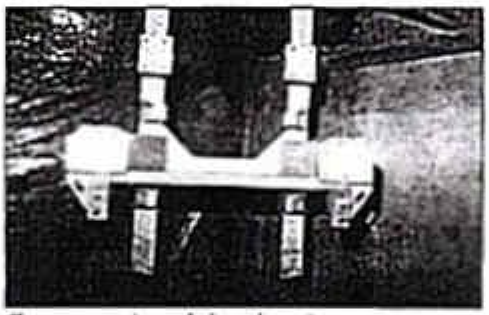
I wrote a letter to England and asked about the frame testing. Mr. Barry Bilbie (Healey frame draftsman) replied, and he



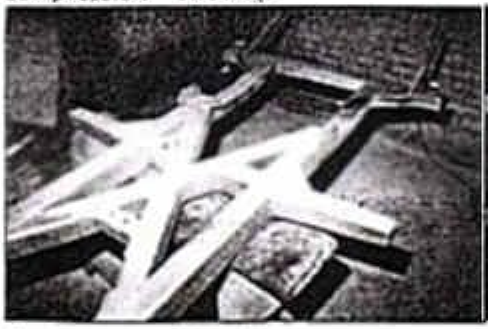
Right chassis rail caped. Good example of poor attempt to solve main rail compression bucking.



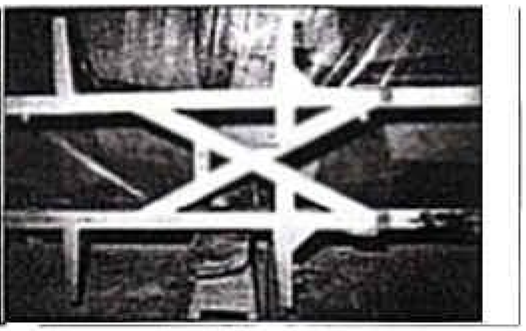
Split front cross member. Right control arm repair.



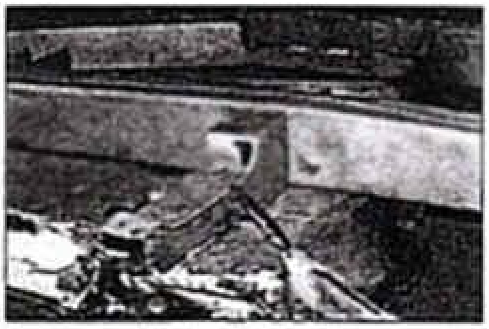
Front section Jule chassis.



Rear section Jule chassis.



Main section Jule chassis.



Buckling of left rail. Patching on right rail. Decayed front outrigger.

thought he remembered a leverage bar being fastened to the frame at the rear axle location. As he remembered the tests, weights were applied to one end of the bar to apply torsional frame stress.

Both of these sources, Mr. Healey and Mr. Bilbie, indicated that the structure of the car was tested using static conditions to verify the design. Fatigue (i.e. dynamic) testing was not performed.

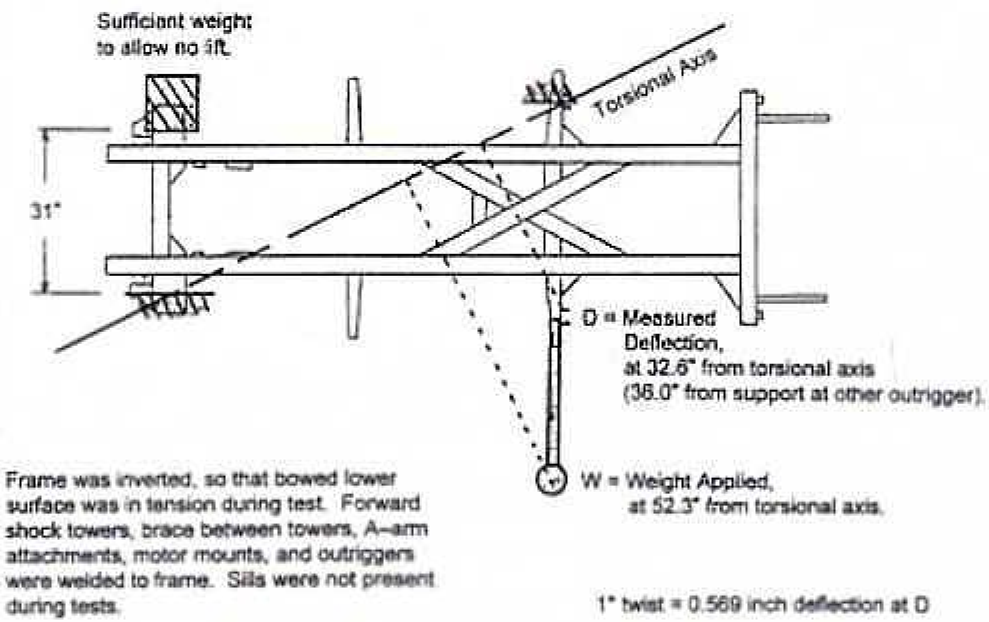
I decided the quantitative comparison should include reverse engineering and reproduction of these original design criteria. It was decided to mathematically calculate the static frame bending stress and re-perform the Geoff Healey torsional test on both an original BJ8 frame and a Jule frame.

In order to estimate the bending stress along the main frame tubes, the overall weight of the car and its heaviest components would have to be determined. Mr. Jansen drove two cars, a BJ7 and a BJ8, to the local weigh station and had the front axle, rear axle and overall weight recorded. The average total weight of these two cars (without driver or passenger) was 2,680 pounds. The weight distribution of both cars was 48.5% front and 51.5% rear. Weight of a fully dressed BN4 motor and transmission in my garage including exhaust manifold, generator and starter was determined to be 764 pounds. Taking these weights and spring forces in to account, an ANSYS computer model was generated and given the task of applying the other 1,916 pounds to the frame at four locations: front shock towers, forward outriggers, rear outriggers, and rear cross member. The computer model results were plotted on an engineering bending moment diagram.

(continued on page 17)

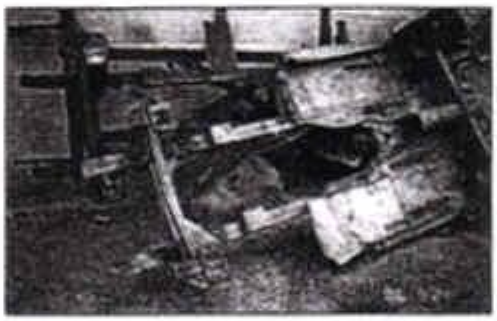
	Original frame	Jule frame
Weight (lower is better)	135 pounds	215 pounds
Wall thickness (AISC code is 0.085 inch min.)	0.072 inch	0.125 inch
Maximum bending stress (lower is better)	7,630 psi	4,580 psi
Torsional stiffness (higher is better)	635 ft. lb./degree	1,550ft. lb./degree

Torsion Test, Practical



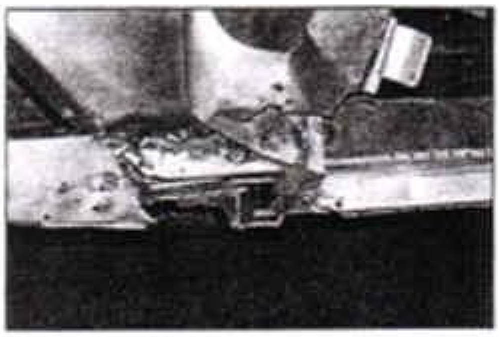
Shearing of left chassis rail just in front of outrigger.

Severe decay of spring carrier – rear outrigger.

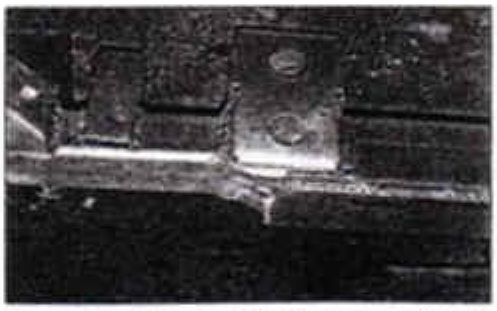


Discarded chassis. Notice chassis closest to wall Bottom rail caped with flat bar.

Rear shock plate BN7.



Common finding in lower front bulkhead corners.



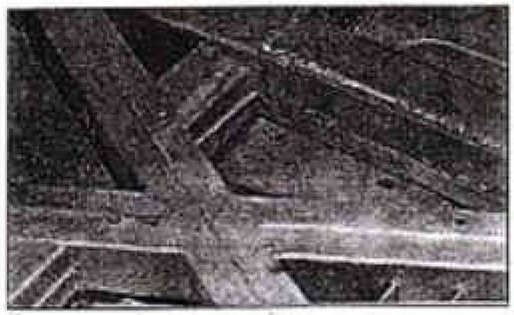
Poor attempt to repair very common problems with engine mount, control arm brk and chassis buckling.

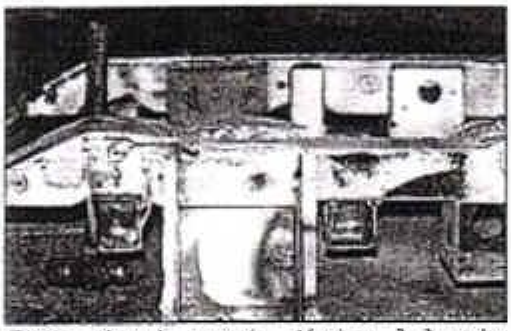
Jule Chassis *(continued from page 13)*

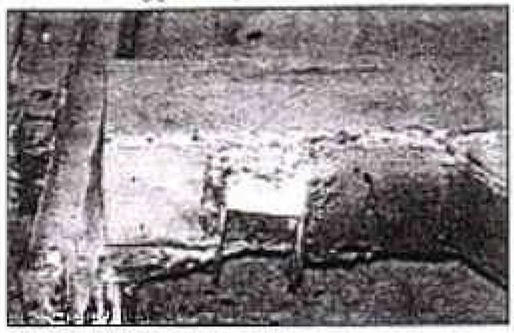
This diagram revealed that the maximum static bending moment on the main frame rails is about 747 ft.-lb., and is located at the junction of the forward outriggers. Incorporating the varying box section height of the frame rails as a function of length, maximum static bending stress along the bottom surface of the main frame rails at the junction of the forward outriggers is 7,630 psi.

So as to determine the static safety factor of the original frame design, I removed some metal from the main frame rails of my BN6. Mechanical testing revealed the yield strength to be approximately 45,000 psi and the ultimate tensile strength to be approximately 50,000 psi. These values indicate that the original safety factor to prevent yielding of the frame is about 5.9. A book by Mr. Forbes Aird suggests a static safety factor of 6 is typically used in frame design. Isn't it interesting how well these numbers match?


Typical rear outrigger repair.


Rear outrigger repair.


Front chassis repair. Notice 3x3 tube sectioned in.


Lower rail repair.

Review of the current American Institute of Steel Construction (AISC) and American Welding Society (AWS) codes suggest, however, that the static safety factor may not be this high. For box tubing of the 3 x 4 inch size, the AWS code specifies a minimum wall thickness of 0.109 inch. The AISC minimum wall thickness per code is 0.085 inch. The AISC code is probably the more accurate of the two, as it was significantly overhauled in 1961 to better account for buckling of thin walled tubing. Note, this was 10 years after the Big Healey was designed. This means that the 5.9 static safety factor for the original frames may not be achievable due to compressive buckling of the tube at a lower stress. Buckling of the main frame rails has occurred to my BN6 forward of the X-member, and in particular around the motor mounts. To me it appears the AISC code is accurately predicting the behavior of thin walled tubing. I tried to decipher the AISC code requirements for walls thinner than 0.085 inch, but the required amount of information was more than I had available. I looked up the gauge size nearest to 0.085 inch and found it to be 0.0937 inch (13 gauge). For the reasons stated above, it is my opinion that replacement frames should be produced in 13 gauge or heavier material to avoid premature buckling.

The Jule frame is manufactured from 1/8 inch wall 3 x 4 inch rectangular tubing. This tubing has sufficient wall thickness to meet both AWS and AISC code requirements, as would be expected since no modern day manufacturer of hollow structural tubing wants the liability of producing non-code compliant product. Using the same bending moment of 747 ft.-lb., the maximum static bending stress on the lower surface of the main frame rails at the forward outrigger is lowered to 4,580 psi. The Jule frame, therefore, has a static bending strength 40% greater than the original. This improvement in strength would noticeably reduce the amount of frame deflection under the same loading conditions.

Torsional testing was performed at Jule Enterprises. An original BJ8 frame with a butt welded patch in the rear cross member was tested. New original style outriggers were installed. The frame was inverted so as to put the bottom surface in tension during the test, just as it is in service while driving down the road. Metal blocks were placed under a forward shock tower and the diagonally opposite outrigger at the leaf spring bracket. A lever arm was firmly attached to the outrigger on the other side of the frame, just outboard of the leaf spring bracket. The other forward shock tower was held firm by placing metal blocks under it and a weight in excess of 800 lb. on top of it. Mr. Mike Allore showed up with two height gauges and assisted with the test. A height gauge was placed over the leaf spring bracket with the attached lever arm, and over the diagonally opposite forward shock tower with the 800 lb. load. Weights were applied to a specific location on the lever arm and height gauge readings were recorded with each weight addition. No movement of the forward shock tower was permitted, as was confirmed by the height gauge. A linear plot of weight

Jule Chassis

versus deflection was produced. Torsional strength of the original frame was calculated to be 635 ft.-lb./degree of twist.

This same torsional test procedure was reproduced on the Jule frame. The linear plot for the Jule frame revealed its torsional strength was 1,550 ft.-lb./degree of twist. This was a 140% improvement over the original Austin-Healey frame.

Weights of the two frames were recorded and metal efficiency calculated. The original frame weighed 135 pounds. The Jule frame weighed 215 pounds. Torsional efficiency of the two frames was 4.70 (ft.-lb./degree/ lb.) for the original frame and 7.21 (ft.-lb./degree)/ lb. for the Jule frame. The Jule frame, though 80 lb. heavier, was more efficient in resisting applied torque.

Visual appearance of the two frames is similar. Some details are different between the original Austin-Healey frame and the Jule frame. The front cross member lower surface on an original Austin-Healey frame is on the same plane as the main frame rails. This lower cross member surface is 1 inch above the lower surface of the main frame rails on a Jule frame, since the main frame rails on a Jule frame are a constant 3 x 4 inch height. The "L" flanges on the outboard side of the shock towers (facing the coil springs) are of a constant curve design on the original Healey frame. The Jule replacement frame uses two straight lengths of "L" flange welded together at the intersection to simulate the curve. Sway bar attachments for the original frames are spot welded nuts inside the tubes. The Jule frame uses self-threading screws directly into the thickness of the 1/8 inch thick main frame rails. Rear suspension differences are a thicker redesigned rear shock tower plate, and leaf spring brackets designed specifically for use of BJ-8 springs and shackles.

I have never driven a Jule framed car, so I can not offer this comparison. But, with somewhere around two hundred of these frames having been produced to date, chances are somebody with a Jule framed car can be found at a local or regional meet.

My hope is that these comparisons help if a replacement frame is being considered. I have tried to describe the major design differences and performance characteristics of the two frames. It is important to state that all testing was static only, no dynamic (fatigue) loading conditions were applied. These tests, and the original tests performed by Geoff Healey, do not predict vulnerability of either design to fatigue conditions imposed while driving the car. Fatigue strength is highly dependent on design and workmanship.

Editor's note: David Seib is a senior metallurgist for Dresser-Rand Products.

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A note from Jule Enterprises: I would like to thank David for his excellent article and for taking the time to do this research.

I would also like to mention that in the 12 years that we have been building and installing the JULE replacement chassis, we have yet to see any fatigue in our product. We believe the alterations we made to the original design are responsible for the improved performance and handling. We felt that patching or duplicating the original chassis would only replicate the fatigue problems being encountered by Healey owners.

The JULE chassis is helping to bring driving pleasure to Healey enthusiasts around the world.

- Martin Jansen