Department of Mechanical Engineering
Mankato State University

A

SENIOR DESIGN

(ME - 448)

Engine Dyno Project

Group Members

[redacted]

June 3, 1996

OBJECTIVE:

The purpose of this project is to design, build, and test an engine stand and mount an engine to an eddy current dynamometer. This will eventually give students hands on instruction of the otto cycle by experimentally determining horse power, air and fuel flow rates, heat transfer rates of the cooling system, and exhaust emissions of a spark ignition engine in order to do an energy balance on the system.

PROJECT SUMMARY:

The project status as of June 3, 1996 is as follows.

- The engine dyno was delivered on January 5, 1996. Physical Plant moved the dyno into the room and left it on the shipping crate. Brackets were designed and built to remove it from the pallet and set it in place.
- A cost analysis and engine performance evaluation was done to select an engine to be used on the dyno. Costs and performance curves were compared on two engines that were donated to MSU (V-6 and V-8 Chrysler engines). The decision was made not to use these engines because their performance exceeded the performance of the dyno. The cost analysis and performance curves are in the appendix of this report. We decided to use a 1.6 liter 4-cylinder chevette engine that was donated to the AET department after the engine specifications for the chevette engine were obtained. The performance from this engine will work perfect for the dyno.
- The engine was removed from the chevette and it was cleaned.
- The exhaust system design and assembly has been completed.
- The final design for the engine stand has been completed. Force calculations along with load simulation and factor of safety calculations were done before constructions began. These calculations are also in the appendix.
- Once we felt confident about our calculations, we began construction of the engine stand. The stand is now complete.
- Measurement devices have been selected and their placement has been decided. We are using K-type thermocouples for measuring all temperatures and a turbine flow meter to measure coolant flow rate.
- A magnehellic gage is used to measure change in pressure.
- Calculations were done to determine the geometry of the long radius nozzle used to measure air flow rate. These calculations are in the appendix.
- An air chamber was selected and mounted to the engine stand.
- Heat exchanger design has been completed . The calculations are in the appendix.
- Design of a drive shaft is complete, but the coupler needed to mount to the dyno is still at API Manufacturing being made as of June 3, 1996.
- The control stand design and construction has been completed and the assembly of the recording devices and ignition switch is also done.

- The engine has been tested for operation and the pressure gage, thermocouples, and ignition switch has all been tested and found to be in proper working order. The Omega turbine flow meter has not been hooked up due to time constraints.

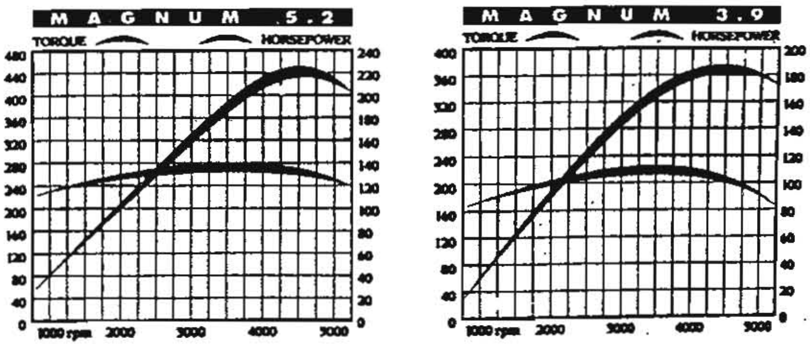
DESIGN APPROACH:

1. Select an engine to use with the dyno.
2. Design and assemble the exhaust system.
3. Set-up the dynamometer and support equipment in the engine test lab.
4. Design, build, and test the engine stand.
5. Select a drive shaft and design the couplers to mount to the engine and dyno.
6. Design and build the control stand, as well as mounting all measurement equipment.
7. Design or choose measuring devices.
8. Refine the design and test as time allows.

CONCEPTS AND DESIGN ISSUES:

1). Our engine selection was limited to the Dodge Magnum 3.9 liter V-6 and 5.2 liter V-8 engines which were donated to the university by Chrysler Corporation at the beginning of this project. A cost analysis was done to finalize the assembly of the V-6 engine and this is shown in Appendix A of this report. This proved to be too expensive and the performance of the V-6 engine exceeded the power absorption capability of the dyno, as can be seen from the engine performance curves in figure 1. The engine specs and dyno specs are also in Appendix A of this report.

MAGNUM SMPI
5.2-liter V8
- **230** ***horsepower*** *at* 4,800 *rpm.*
- **280** ***pound-feet of torque*** *at* 3,200 *rpm.*



MAGNUM SMPI
3.9-liter V6 *has the same features listed above on the* MAGNUM 5.2-liter V8 *for best-in-class* V6 *power:*
- **180** ***horsepower*** *at* 4,800 *rpm.*
- **225** ***pound-feet of torque*** *at* 3,200 *rpm.*

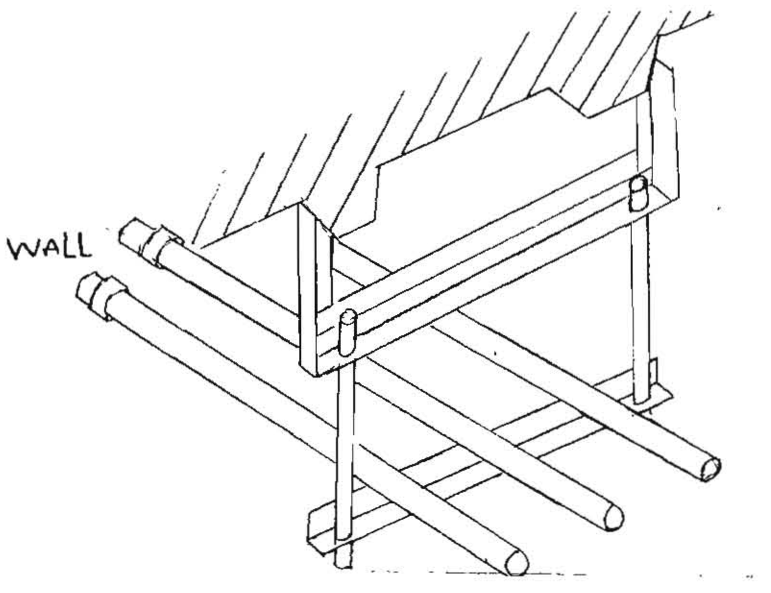
Torque, Hp curves for the V-6 and V-8 engines
Figure 1

It was for this reason that we consulted with Dr. Jones from the AET department to find another engine. He informed us of a 1981 chevette that was donated to the university and said we could purchase this for our project if it would fit our specifications. We did some research and found the information from the Technical Assistance Center, Chevrolet Motor Division, Troy Michigan. The following performance specifications were obtained and the data sheets for the chevette engine are in Appendix B.

Performance specs. for the chevette engine:

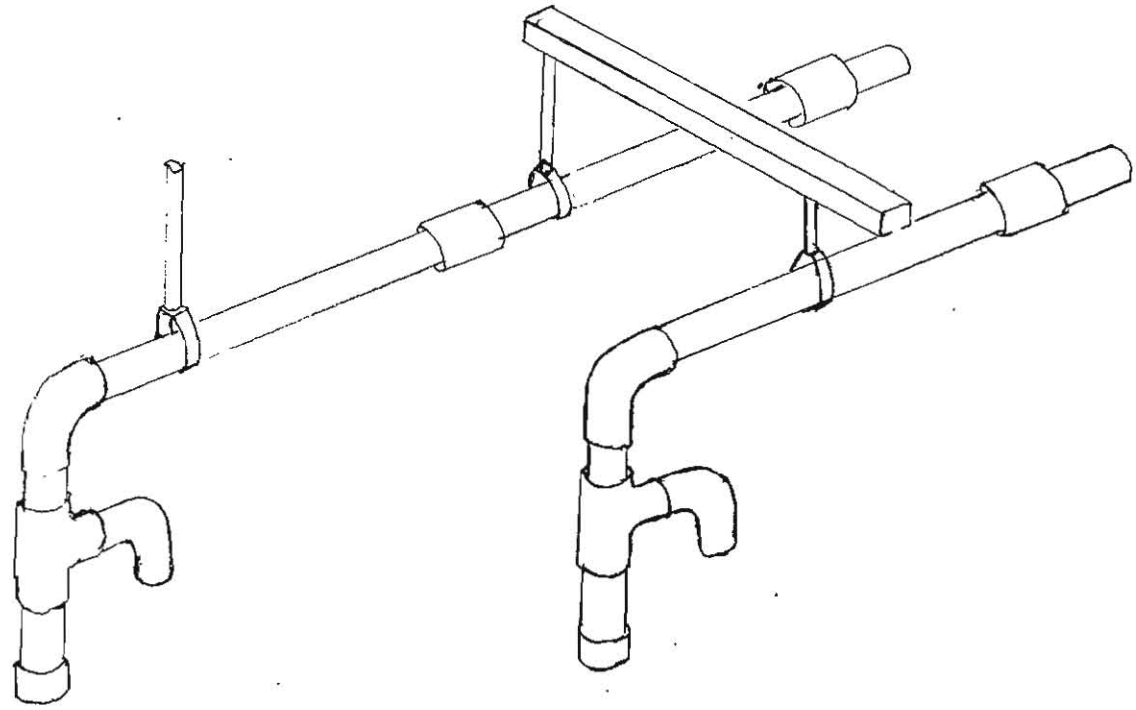
- 1.6 Liter 4 Cylinder Engine
- 2 Barrel Carburetor
- 90 bHp at 5200 rpm
- 60 ft-lb Torque
- Dressed Engine Weight = 320 lb.

2). Once the selection of the engine had been completed, we focused our attention on finalizing an exhaust system design. We started with a concept of making a single exhaust line for the whole room, but this would not allow for more than one engine to be tested at a time. For this reason we decided to hang a separate exhaust line for each engine station to be used in the room. Our first concept is shown in figure 2. A bracket was made to be mounted across the supports in the ceiling and then two threaded rods were attached to this bracket and another bracket was used to support the 4'" galvanized, schedule 40 pipe.



Concept for Exhaust System
Figure 2

This proved to be too cumbersome so we changed the mounting to be as shown in figure 3. This was our final design. A "u" channel was obtained from physical plant to mount to the cross beams in the ceiling. We hung threaded rod from this bracket and then attached a clevis hanger to the end of the threaded rod. The clevis hanger is used to support the pipe. This design allowed us much more flexibility in positioning the pipe.



Final Design for Exhaust System
Figure 3

We encountered two major problems during the installation of the exhaust. One major problem was that the pipe was too heavy to lift up into position. We solved this problem by hanging a chain hoist above the pipe and then we lifted the pipe into position using the hoist. Once we hoisted the pipe into, place we discovered the pipe installed through the wall during the construction of Trafton East was installed very crooked. This made mounting the exhaust line very difficult and it also made our installation look very poor. We decided that this was not acceptable so we drilled holes in the cement block and straightened the pipes coming through the wall. We then sealed around the pipe with a fire retardant caulking.

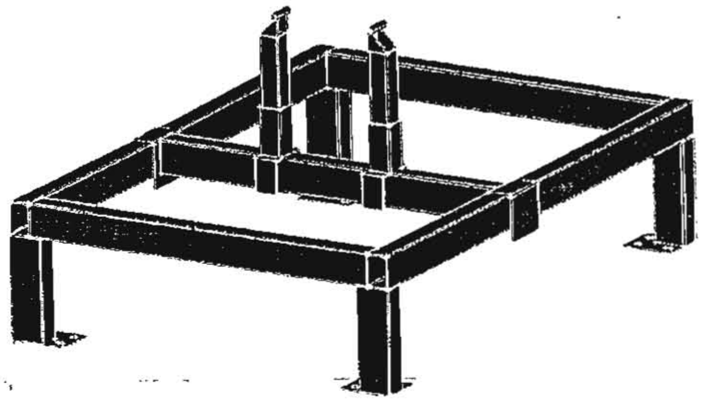
3). As we were installing the exhaust, we were developing a method to remove the dynamometer from the shipping skid so we could move it into position. The dynamometer weighs approximately 4700 lb. so we could not physically lift the dyno, nor could we get a forklift in to the room to lift the dyno due to space constraints. After several ideas were discussed, we agreed upon making two brackets to be mounted on the top of the base of the dyno. Once the brackets were made and mounted, we used two pallet jacks to lift the dyno off the skid and move it into position. Once the dyno was placed into position, we began work on concepts for the engine stand.

4). Our major concerns while designing an engine stand were as follows.

- The ability to support the stand with minimal deflection and vibration. We decided that in order to minimize any vibration in the frame, a deflection of no more than .010" would be acceptable.
- The stand must be able to handle the loads of several different types of engines. The maximum loads that are to be applied to the stand are based on the performance specifications for the magnum V-8 engine and are as follows:

    - 230 Hp at 4800 rpm
    - 300 ft-lb. torque at 3200 rpm
    - 450 lb. dressed weight

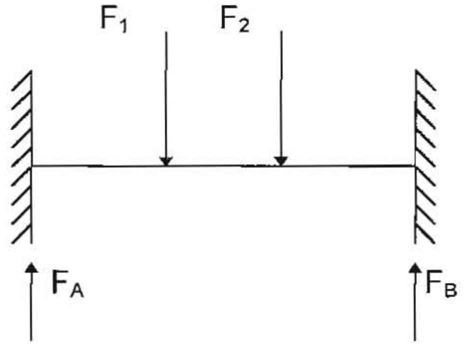
- Since the stand must be able to accommodate several different types of engines, we designed it to have sliding adjustments in the horizontal and vertical direction. Figure 4 shows the final design of the engine stand.

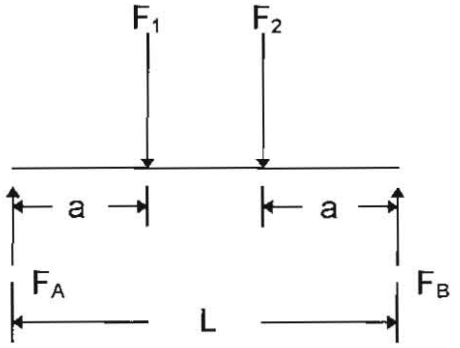


Final Design for Engine Stand
Figure 4

Force Calculations for the Engine stand:

Two cases were investigated during our force analysis of the main frame. For the first case we assumed a statically indeterminate case as shown in figure 5 when analyzing the cross support. Equations 1 and 2 were used to determine the forces at each end of the cross support and equation 3 was used to find the maximum deflection. The forces at each end of the cross support were found to be F_A = 435.02 Lb. and F_B = 14.98 Lb. when the engine is accelerated to 3200 rpm.





Statically indeterminent case
placed

Figure 5

Two concentrated forces symmetrically

Figure 6

Equation 1: $\Sigma F_y = 0 = F_1 - F_A - F_B + F_2$

Equation 2: $\Sigma M_A = 0 = F_1 *(L_1) + F_2 *(L_2) - F_B *(L)$

Equation 3: $Y_{max} = PL^4 / 384\ EI$ Indeterminent Case

E of CRS = $29 * 10^6$ psi

$I = 1/12\ [bh^3]_{OD} - 1/12\ [bh^3]_{ID}$

Equation 4: $Y_{max} = [Pa / 24\ EI] * (3L^2 - 4a^2)$

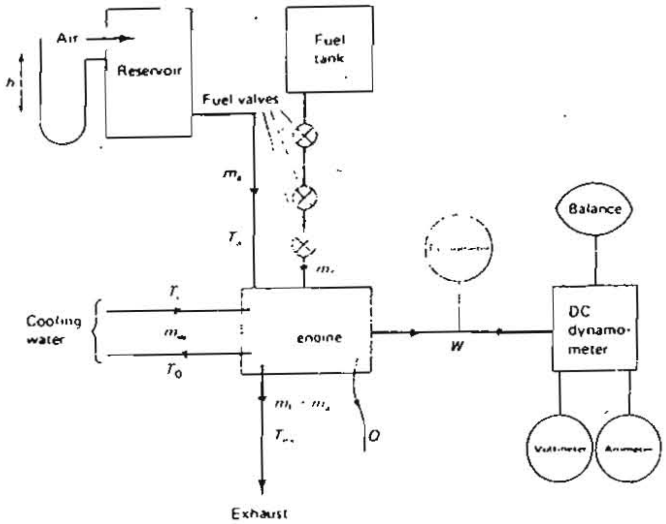
For the second case, we assumed two equally concentrated forces symmetrically placed on the cross support using equation 4. These forces were found to be the same as with the first case. We approached the remainder of the force analysis using this same approach and can be found in the appendix of this report. The maximum deflection in the cross support was found to be .005" and the main frame member was found to be .003". These deflections fall well within our specifications so we decided to begin construction on the frame. We also employed Aries to do a stress analysis on the main support that will be connected to the engine mount. The results are also shown in Appendix C of this report.

For the head pieces that support the engine mounts, we decided to do the force simulation on Aries. The shape of the piece was determined mainly for ease of use in the simulation. The loads were added and a graph of the output in terms of deflection was obtained and deemed satisfactory at 0.00012 inches of deflection. The construction of this piece was halted due to improper tooling. The cutters necessary to do the job were damaged so a useable piece was not obtained. An alternate support was then designed and calculations for the stress and deflection were done manually. The equations used are:

Equation 5: Y = PL/AE
Equation 6: Sigma (normal) = F/A

The stress was calculated to be approximately 1111 psi, which is well below the allowable stress. A factor of safety was calculated as FOS = 27 and the deflection was calculated and the results gave a maximum deflection of Y = -0.0008 inches. This is well within our design limits so the fabrication was completed. The schematic of the piece and calculations are also in Appendix C.

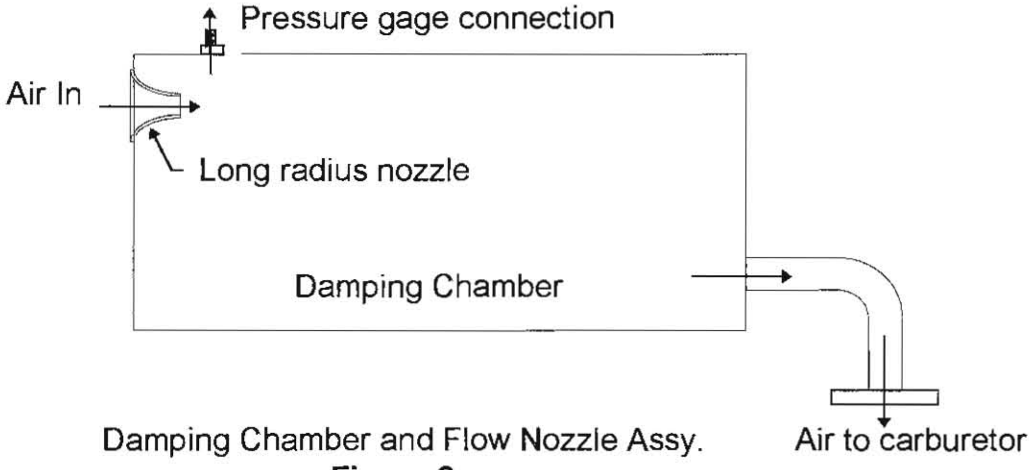
5). Measuring devices and their placement have been investigated and figure 7 shows the placement of the various devices that we used.



Placement of Measuring Devices.
Figure 7

- Temperature is measured using quick disconnect K-Type thermocouples. Air temperature into the engine, and water temperature in and out of the heat exchanger, and exhaust temperature are monitored.
- Pressure drop across the air intake nozzle is measured using a magnehellic gauge.
- Fuel in will be measured by using a scale.

- Air flow is measured using a long radius nozzle in conjunction with a damping chamber as shown in figure 8. The design process for this assembly is as follows and calculations are in Appendix D:



Damping Chamber and Flow Nozzle Assy.

Figure 8

Design parameters:

The design of the air chamber and flow nozzle is based on SAE standard for test procedures of dyno facility. See SAE J1088 February '93 for reference.

- The measurement should consist of a laminar flow meter used in conjunction with a pressure wave damping chamber in order to damp out pulsation in air flow into the carburetor.
- Internal volume of pressure vessel: not less than 100 times the displacement per cylinder.
- Pressure drop: not to exceed 100 pascal.

Properties and symbols:

- Room temperature = 20° C
- Density of air (ρ) = 1.21 Kg/m^3
- Cross section of carburetor inlet (A) = 0.0014 m^2
- Displacement of cylinder (d) = 1.6 liter (98 in^3)
- Volumetric flow rate (Q) and ft^3/min (CFM)
- RPM (max) = 5200
- Velocity into carburetor (V)
- Pressure Drop (ΔP) = 100 pa
- Vertical distance from nozzle inlet to carburetor inlet (Z) = 0.254 m (10")
- Nozzle cross sectional area (A_N)
- Nozzle diameter (d_N)

Assumptions:

- incompressible flow
- steady state
- constant pressure and temperature
- fixed volume

Calculations:

Q = CFM = (RPM *d)/3456 = 0.069 m^3/s (147.5 ft^3/min)
V = Q/A = 49.3 m/s

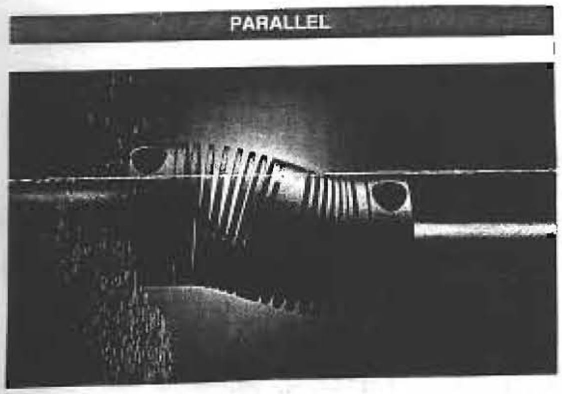
From Bernoulli's equation: $P_1/\rho_1 + V_1^2/2 + gZ_1 = P_2/\rho_2 + V_2^2/2 + gZ_2$

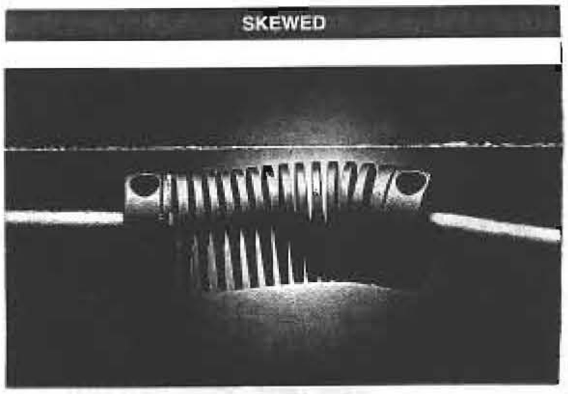
$$V_N = [\,V^2 - \Delta P - gZ\,]^{1/2}$$
$$\therefore\ V_N = 59.3\ m/s$$
$$V_N A_N = VA$$
$$\therefore\ A_N = 0.0012\ m^2$$
$$d_N = 0.039\ m\ (\ 1.5"\ )$$

6). The design of the drive shaft is based on material from " The Design of U-joints and Drive Shafts", located at MSU library, (TJ 1059.S3313) and the calculations and related material are in Appendix E. We explored three drive shafts to be used as the coupler between the engine and dyno.

- The first concept was to use a drive shaft with U-joints on each end of the drive shaft. After further investigation, we decided against this design because the U-joints did not offer enough flexibility for mis-alignment as is shown in Appendix E. The maximum degree of mis-alignment is 3°. We need at least 10° due to the length of the shaft needed to reach the dyno, and for other engines to be mounted to the dyno with a certain degree of flexibility.

- Our second concept was to use a flex joint as shown in figure 9. This offers excellent performance for the skewed, angular, and parallel mis-alignment, but the maximum allowable torque was 100 in-lbs. Our minimum torque is 60 ft-lbs of torque.

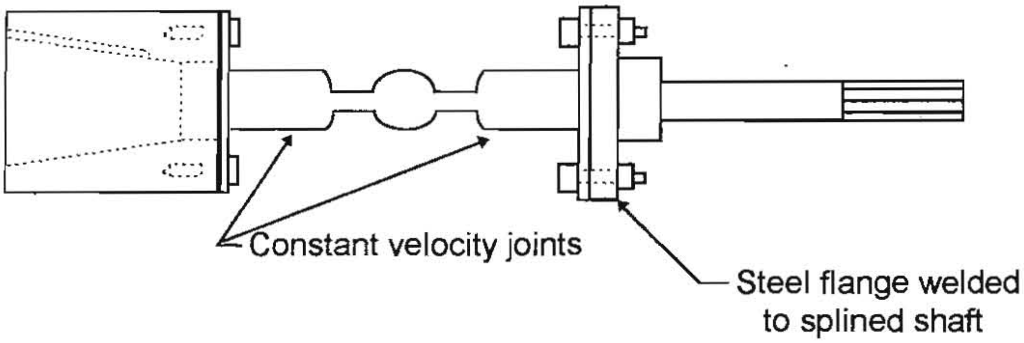




Flex Joint
Figure 9

- Our final design choice is the use of a drive shaft with a constant velocity joint on each end of the shaft. This allows for skewed, angular, and parallel mis-alignment together with the torque requirements for our application. After consulting with Catco drive train specialists, we selected a drive shaft made for a 4 wheel drive Bronco. The splined shaft from the transmission was used in conjunction with a drive plate to be mounted on the engine side of the drive shaft and a couple was designed for the dyno shaft as shown in figure 10. The design specifications and calculations are as follows:

Drive Shaft Design



Drive Shaft Assembly
Figure 10

Design specifications:

Acceptable torsional deflections for the obtained shaft are:

- Angle of twist (ϕ) = 0.08° per ft. for the 1.67 ft shaft
- ϕ = 0.13°

Angular deflection (δ) calculations using the following equation:

$$\delta = 584TL/Gd^4$$

where,

L = 1.67 ft (length of the shaft)
T = 300 ft lb (Torque applied)
G = 12e6 lb/ft^3 (shear modulus of steel)
d = 0.208 ft (average diameter of shaft)

$$\delta = 1.67e\text{-}4 \text{ ft } (0.002")$$

$\therefore$ **ϕ = 0.09° (1.6e-3 radians)**

Which is within our acceptable limit of 0.13°.

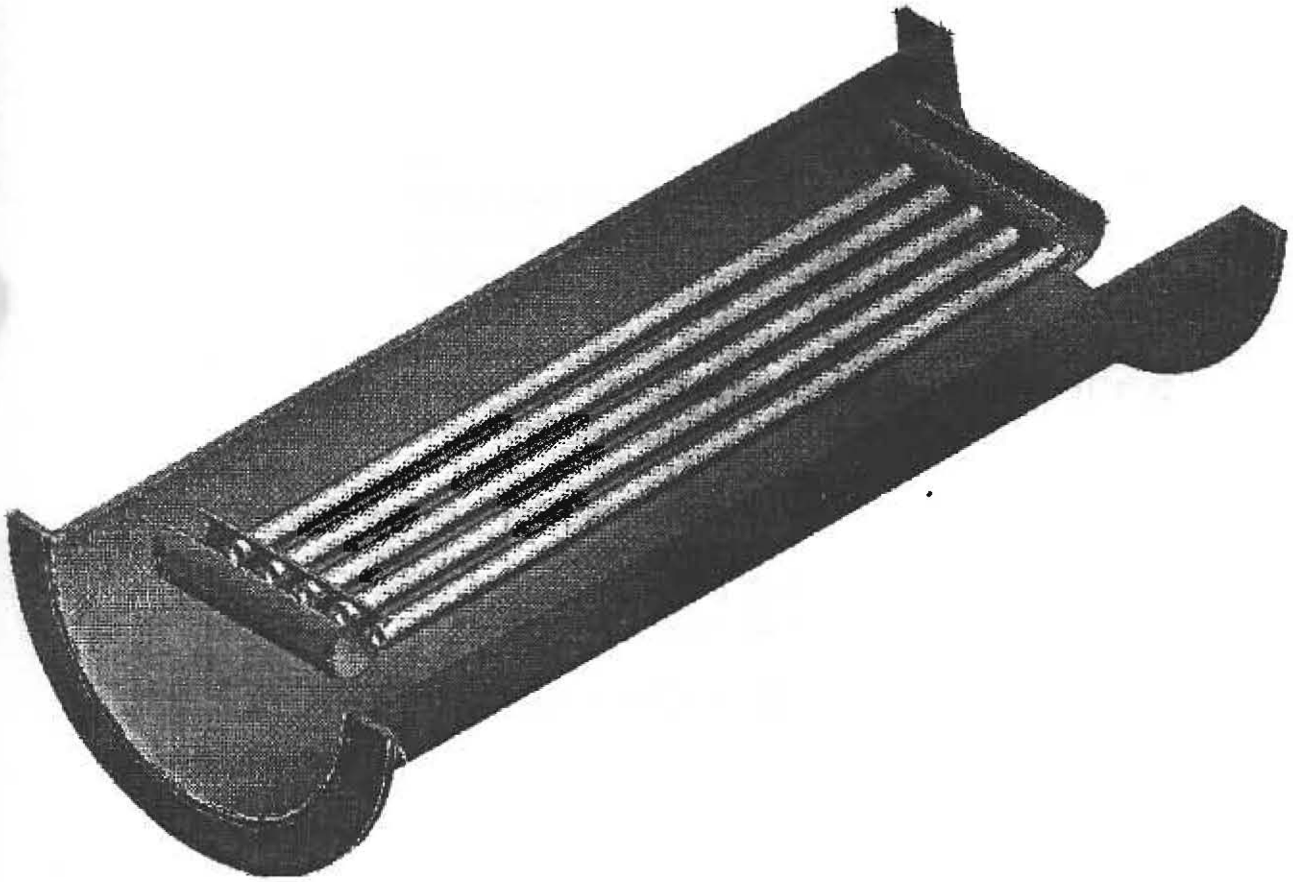
7). Heat exchanger design for the cooling system resulted in a counter flow, closed system heat exchanger as shown in figure 11. Reasons for not using the existing radiator are as follows:

1). The current radiator was damaged and leaking.

2). The use of a glycol - air exchanger in the room could significantly raise the air temperature in the room, causing changes in the density of the air and possibly causing discomfort among the students.

3). A water glycol counterflow exchanger would be relatively inexpensive to build, compared to a purchased, fully fabricated one.

4). It made it easier to regulate the operating temperatures of the engine by controlling the cold water inlet to the exchanger using a valve.



Heat Exchanger Design
Figure 11

HEAT EXCHANGER DESIGN:

The basic design was the use of copper tubing for the high pressure side and a CPVC pipe found in the EPL for a cold water bath.

Several iterations were carried out to determine the size and length of the copper tubing using the NTU method. Some research was done concerning the amount of water or glycol that would be required for the base calculations of 200 HP. Several calls were made as to flow rates specified by area radiator repair shops and also by doing a calculation to determine the flow. Optimum flow for 200 HP was about 14 GPM. We chose a trial I.D. of 1/2 inch pipe. We then reduced the velocity of the water through the tubes by increasing the number of tubes in the exchanger. Our final calculations arrived at a length of 3.12 meters. This turned out to be a few inches too long to fit in the CPVC tank, so another tube was added to use up the extra length left over. To help the mixing of the flow, several fins were added to the core. Clear end plates were also used to help students see what is inside the exchanger. The cold water flow is controlled by a simple faucet style valve at the inlet side. The tank then fills until the overflow port is reached at the top of the other end of the tank. waste water then flows out through a rubber hose to the drain. In the event of a problem with the core, both end plates can be removed to gain access. The calculations are listed below.

Design Specifications:

- Mass flow rate of glycol = 14 GPM =.928 kg / s
- Volumetric flow rate of glycol = 8.768 E -4 m^3/s
- Mass flow rate of water = .5 kg /s

- Operating temperatures:

  Th_{in} = 235° F = 112.7° C Th_{out} =220° F = 104.4° C
  Tc_{in} = 60° F = 15° C

- Specific heats were:

  cp glycol = 2742 j/(kg K) @ 100 C
  cp water = 4182 j/ (kg K) @ 15 C

- Effectiveness = cp_h (Th_{in} - Th_{out})/(C_{min} (Th_{in} - Tc_{in}))

  $c_h = m_h\ cp_h$ = 2544 w/K
  $c_c = m_c\ cp_c$ = 2090.9 w/K
  $c_{min} = c_c < c_h$ => 2090 .9 w/K
  effectiveness = .1038 %   0.822 or 82.2%

This data was then used to calculate the following results:

Glycol

Re_i= 11000
Nu_i = 99.8
h_i = Nu k/ D_i = 2068.2 w/m^2 K

Water

Re_o = 4800
Nu_o = 10.5
h_o =3400 w/m^2 K

U_{min} = 1/(1/h_i + 1/h_o)   NTU = .115 C_{min} = 2090.9 w/K

A = NTU C_{min}/ U_{min} = .187 m^2   **L= 3.12 m of pipe**

After the length of the pipe was determined and the fabrication was completed, the system was put on-line to see what kind of cooling was taking place. The system at idle and no load situations above idle required only a minimal amount of flow through the cold side of the exchanger. Testing for high heat loss can not be done until loading of the engine can take place next year but the fact that the system was designed for 200 HP and the current engine is 96 HP, little doubt remains that the system will not cool properly. More concern should be addressed with the possibility of leaks in the system due to time and use around the flanges that were bonded to the tank and around the hot side inlets to the tank.

CONCLUSION:

The objectives that were stated in the fall report have been successfully met. The engine will run on the stand with no problems, the measuring devices are working properly, the control stand has been fabricated and has space for future data readout devices. The only unfinished business concerns the shaft coupler. The shop employed to fabricate it will not have it completed before the end of the quarter. It will be ready about one week after the quarter. We have met the criteria that was placed before us in the fall of this school year.

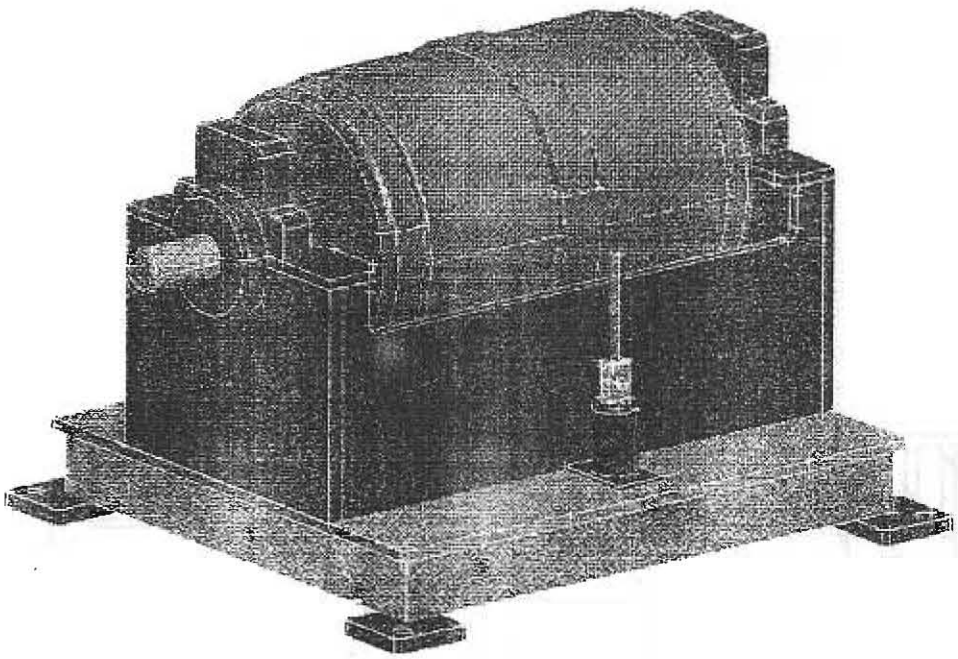
ITEMS OF CONCERN:

There are a few things that next year's group needs to be aware of concerning the operation of the engine. There will be a need to prime the engine if it sits for a while to get it to start. There is also oil available in the room as it needs to be changed. Care must be taken when running the engine without a tachometer on-line to monitor the rpm. The engine doesn't

have a rev limiter to protect it from running over the red line. The clutch parts are all in the room in the event that the next group wants to install it. It may be useful to use the clutch to run the engine under no load cases to determine the no load heat output. It may also be easier to start the engine with the clutch disengaged than using the dyno as a starter. In the event that the dyno is used as a starter, the wiring MUST be changed for the ignition system to prevent the starter from engaging.

APPENDIX A

- Engine and Dyno Specs.
- Cost analysis for assembly of Engine



DC Dyno 2000 specifications

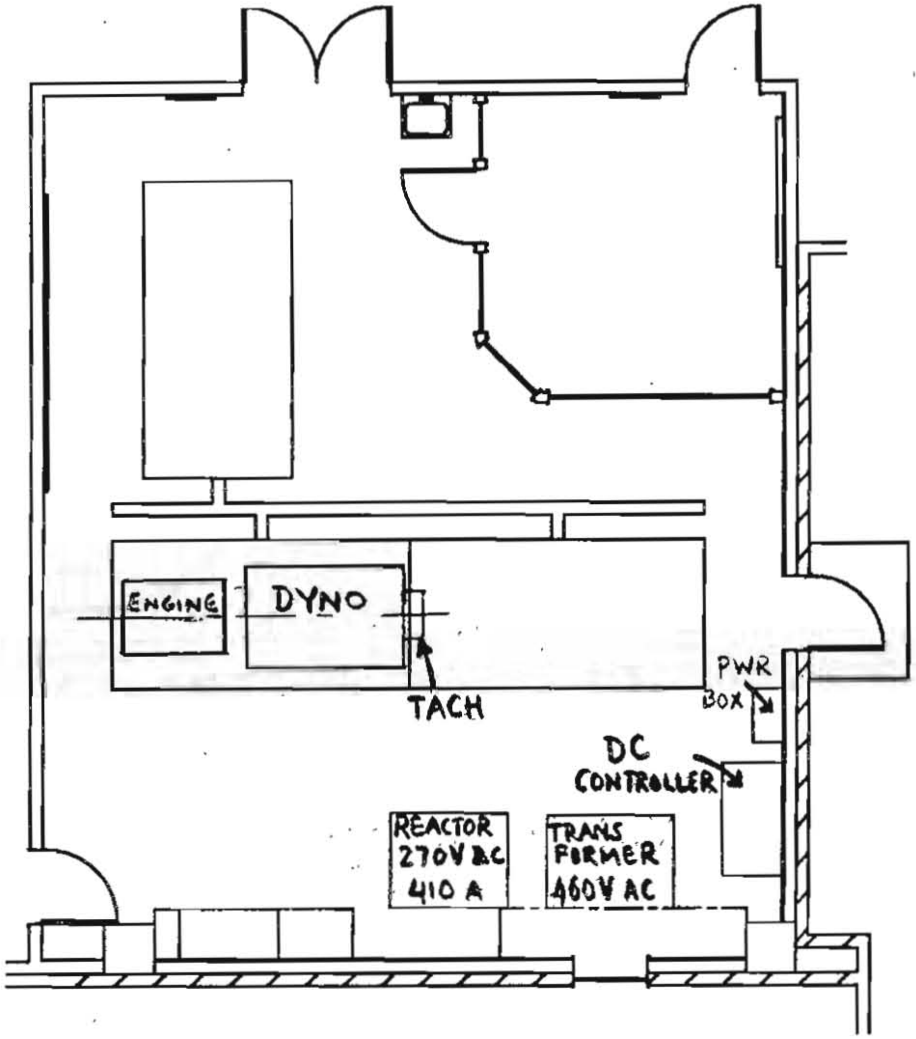
50 " X 56" X 22 "

150 Hp absorbing 120 Hp generating (@ 125 % for 60 s)

250 VAC Input / 265 VDC Output

Dynomometer
Senior Design Projec.
11/6/95

ENGINE TEST CELL LABORATORY



MANKATO STATE UNIVERSITY

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5.2-*liter* V8

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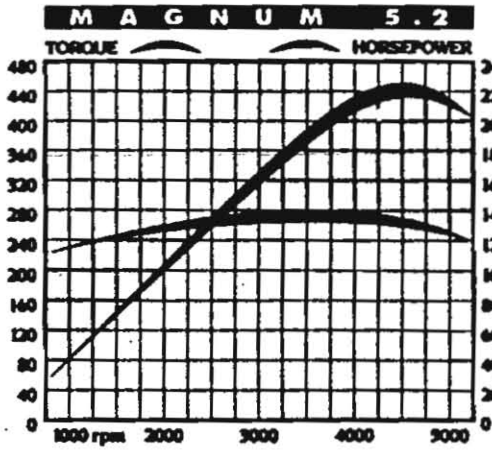

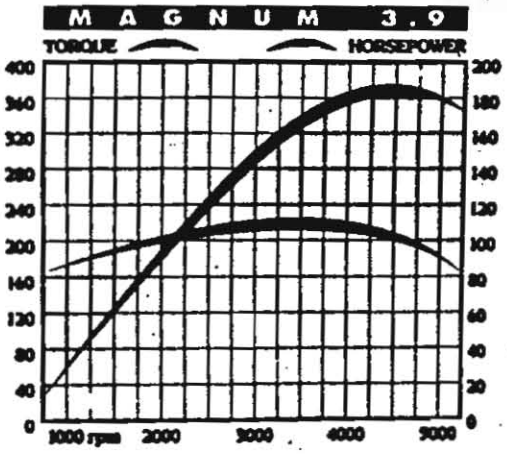

MAGNUM SMPI
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- **180 *horsepower at* 4,800 *rpm.***
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Torque, Hp curves for the V-6 and V-8 engines

Appendix

Cost Analysis to complete the assembly of the V-6 and V-8 engines:

Computer module (Lagers Dodge)	$ 307.50
Wire harness (Lagers)	$ 401.25
Torque converter & hardware (Lagers)	$ 205.29
Starter (Auto America)	$ 109.00
Crank shaft pulley & hardware (Lagers)	$ 33.44
Water pump pulley & hardware (Lagers)	$ 22.32
Motor mounts & hardware (Lagers)	$ 61.81
Exhaust "Y" pipe (Lagers)	$ 72.75
Muffler & Catalytic converter (Champion Auto)	$ 192.00
Total Cost	**$ 1405.36**

APPENDIX B

- Chevette Engine Specs.

MVMA

Specifications Form Passenger Car

1981

METRIC (U.S. Customary)

Manufacturer	Car Line	
CHEVROLET MOTOR DIVISION GENERAL MOTORS CORPORATION	CHEVETTE	
Mailing Address	**Model Year**	**Issued:** SEPTEMBER,1980
CHEVROLET ENGINEERING 30003 VAN DYKE WARREN, MICHIGAN 48090	1981	Revised (•)

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Table of Contents

NOTE:

1. This form uses both SI metric units and U.S. Customary units. The Metric unit of measurement is presented first, and the U.S. Customary unit follows in parentheses.
2. UNLESS OTHERWISE INDICATED:
   a. Specifications apply to standard models without optional equipment. Significant deviations are noted.
   b. Nominal design dimensions are used throughout these specifications.
   c. All linear dimensions are in millimeters (inches), and all mass (weight) specifications are in kilograms (pounds).
3. The General Specifications herein are those in effect at date of completion and are subject to change without notice by the manufacturer.
4. A printed or computer tape supplement containing additional Car and Body Dimensions and/or drawings (based in part on SAE J1100a "Motor Vehicle Dimensions") may be available from the manufacturer.

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Car Line CHEVETTE
Model Year 1981 Issued 9-80 Revised (•)

Car Models

Model Description (Include Line Drawings of Vehicles, if Desired)	Make, Car line, Series, Body Type (Mfgr's Model Code)	No. of Designated Seating Positions (Front/Rear)		Max. Trunk/Cargo Load — Kilograms (Pounds)
CHEVETTE	MODELS	FRONT	REAR	
2-Door Hatchback Coupe	1TB08	2	2	
2-Door Hatchback Coupe	1TJ08	2	2	
4-Door Hatchback Sedan	1TB68	2	2	

NOTE: Any Specifications on the Following Pages that are Specific California Requirements are Indicated Accordingly.

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Car Line CHEVETTE
Model Year 1981 Issued 9-80 Revised (•)

Power Teams (Indicate whether standard or optional)

SAE Net bhp (brake horsepower) and net torque corrected to 85° F and 29.38 in. Hg atmospheric pressure

SERIES AVAILABILITY	ENGINE						TRANSMISSION	AXLE RATIO (Std. first) (Indicate A/C ratio)	
	Displ. liters (in³)	Carb. (Barrels)	Compr. Ratio	SAE Net at RPM kW (bhp)	SAE Net at RPM Torque N·m (lb. ft.)	Exhaust System*		BASE	OPT.
BASE - ALL STATES	L-4 1.6 (98) (L17)	2	8.6:1	70 @ 5200	82 @ 2400	S	MAN 4-SPD - BASE (3.75:1 LOW)	3.36:1* 3.70:1	--
							AUTO '180c'-AVAIL (AUTO '200c'-AVAIL)@	3.70:1	--

* With 1TJ08 only - A/C Not Available

82 N-m · .224168 / 1N · 3.28 ft / 1m

LIMITED SLIP DIFFERENTIAL NOT AVAILABLE.

(@) AIR CONDITIONING NOT AVAILABLE.

*S — Single D — Dual

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Car Line CHEVETTE
Model Year 1981 Issued 9-80 Revised (•)

Engine Description/Carb. Engine Code	1.6 LITER L-4 (98 CID) 2-BBL CARBURETOR RPO L17

Engine — General

Type (inline, V and Angle, Flat)		OHC, INLINE
Location (Front, Mid, Rear)		FRONT
Engine installation position (transverse, longitudinal)		LONGITUDINAL
Number of mtg. points	Front	TWO
	Rear	ONE
No. of cylinders		4
Bore		82 (3.23)
Stroke		75.7 (2.98)
Piston Displacement cm^3 (in^3)		1605 (98.0)
Bore Spacing (C/L to C/L)		91.4 (3.6)
Cylinder Block Material		CAST ALLOY IRON
Cylinder block deck height		198 (7.8)
Deck clearance (minimum) (above or below block)		'0'
Cylinder Head Material		CAST ALLOY IRON
Cylinder Head Volume — cm^3		43.6
Head Gasket Thickness (Compressed)		.031
Head Gasket Volume — cm^3		4.8
Minimum Combustion Chamber Volume — cm^3		42.7
Cyl. No. system (front to rear)**	L Bank	1-2-3-4
	R. Bank	---
Firing Order		1-3-4-2
Recommended fuel (Leaded, unleaded)		UNLEADED
Fuel antiknock index $\frac{(R + M)}{2}$		87
Total dressed engine mass (wt) dry *		144.1 (317.7)

Engine — Pistons

Material			CAST ALUMINUM ALLOY
Description and finish (Flat, dished, dome, etc.)			SUMP HEAD, SLIPPER SKIRT
Mass, g (weight, oz.) — Piston Only			400 (14.11)
Clearance (limits)	Top land		.67-.91 (.026-.035)
	Skirt	Top	.020-.040 (.0007-.0015)
		Bottom	
Ring groove diameter	No. 1 ring		72.65-73.05 (2.860-2.876)
	No. 2 ring		72.65-73.05 (2.860-2.876)
	No. 3. ring		72.53-72.93 (2.856-2.871)

*Dressed engine mass (weight) includes the following: FRONT OF ENGINE FAN TO REAR OF ENGINE BLOCK - INCLUDES ENGINE MOUNTS AND ACCELERATOR CONTROLS.

** Rear of engine — drive takeoff.
View from drive takeoff end to determine left & right side of engine.

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Engine — Piston Rings

Function (top to bottom)	No. 1, oil or comp.	COMPRESSION
	No. 2, oil or comp.	COMPRESSION
	No. 3, oil or comp.	OIL
Compression	Description — Material, coating, etc.	UPPER - NODULAR IRON, MOLY CHANNEL, BARREL FACE (A)
	Width (B)	UPPER-1.943-1.969 (.0765-.0775)
	Gap	.23-.46 (.009-.018)
Oil	Description — material, coating, etc.	(2) RAILS-STEEL, CHROME PLATED (1) EXPANDER-STAINLESS STEEL SS-50
	Width	3.98-4.03 (.157-.159)
	Gap	0.38-1.40 (.015-.055)
Expanders		IN OIL RING ASSEMBLY

Engine — Piston Pins

Material			CHROMIUM STEEL
Length			69.7-70.3 (2.744-2.768)
Diameter			22.992-22.995(.9052-.9053)
Type	Locked in rod, in piston, floating, etc.		LOCKED IN ROD
	Bushing	In rod or piston	NONE
		Material	---
Clearance	In piston		.003-.007(.00012-.00027)
	In rod		
Direction & amount offset in piston			MAJOR THRUST SIDE-1.5(.059)

Engine — Connecting Rods

Material		FORGED STEEL 1141
Mass, g (weight, oz.)		354 (12.49)
Length (center to center)		122 (4.803)
Bearing	Material & Type	PREMIUM ALUMINUM
	Overall length	18.80-19.05 (.74-.75)
	Clearance (limits)	.33-.52 (.013-.060)
	End Play	.11-.32 (.004-.012)

(A) LOWER - CAST ALLOY IRON, TAPERED FACE, BARREL FACE.
(B) LOWER - 1.958-1.981 (.0771-.0780)

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Engine — Crankshaft

Material			NODULAR CAST IRON
Vibration damper type			RUBBER MOUNTED INERTIA
End thrust taken by bearing (No.)			5
Crankshaft end play			.010-.020 (.004-.008)
Main bearing	Material & type		PREMIUM ALUMINUM
	Clearance		.008-.074 (.0003-.0029)
	Journal dia. and bearing overall length	No. 1	51.012 x 17.875 (2.0083 x .7037)
		No. 2	51.012 x 17.875 (2.0083 x .7037)
		No. 3	51.012 x 17.875 (2.0083 x .7037)
		No. 4	51.012 x 17.875 (2.0083 x .7037)
		No. 5	51.000 x 23.875 (2.0078 x .9399)
		No. 6	---
		No. 7	---
	Dir. & amt. cyl. offset		---
	No. bolts/main brg. cap		TWO
Crankpin journal diameter			45.958-45.984 (1.809-1.810)

Engine — Camshaft

Location			IN CYLINDER HEAD
Material			CAST ALLOY IRON
Bearings	Material		STEEL BACKED BABBITT
	Number		5
Type of Drive	Gear, chain or belt		TIMING BELT
	Crankshaft gear or sprocket material		SINTERED IRON, CARBONITRIDED
	Camshaft gear or sprocket material		CAST IRON
	Timing chain	No. of links	100
	Chain or Belt	Width	19 (.748)
		Pitch	9.5 (.375)

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Engine — Valve System

Hydraulic lifters (Std., opt., NA)			HYDRAULIC VALVE LASH ADJUSTERS
Valve rotator type (intake, exhaust)			NONE
Push rods (dia., length, material)			NONE
Rocker ratio			1.6:1
Operating tappet clearance (indicate hot or cold)	Intake		ZERO
	Exhaust		ZERO
Timing (based on top of ramp points)	Intake	Opens (°BTC)	28
		Closes (°ABC)	76
		Duration (deg.)	284
	Exhaust	Opens (°BBC)	72
		Closes (°ATC)	32
		Duration (deg.)	284
	Valve open overlap (deg.)		60
Intake Valve	Material		8440 STEEL, ALUMINIZED HEAD & SEAT, CHROME FLASH STEM
	Overall length		98.245-98.755 (3.868-3.888)
	Actual overall head dia		38.87-39.13 (1.53-1.54)
	Angle of seat & face (deg.)		46,45
	Seat insert material		NONE
	Stem diameter		7.970-7.986(.3138-.3144)
	Stem to guide clearance		.046-.053(.0018-.0021)
	Lift (at zero lash)		9.83 (.387)
	Outer Spring press. & length	Valve closed — N at mm (lb. at in.)	284-320 @ 32 (64-72 @ 1.26)
		Valve open — N at mm (lb. at in.)	743-797 @ 22.5 (167-179 @.886)
	Inner spring press. & length	Valve closed — N at mm (lb. at in.)	NONE
		Valve open — N at mm (lb. at in.)	NONE
Exhaust Valve	Material		ARMCO 21-2 STELLITE SEAT, FULL CHROME STEM
	Overall length		98.70-99.21 (3.886-3.906)
	Actual overall head dia		31.87-32.13 (1.255-1.265)
	Angle of seat & face (deg.)		46,45
	Seat insert material		NONE
	Stem diameter		7.95-7.98(.313-.314)
	Stem to guide clearance		.066-.074 (.0026-.0029)
	Lift (at zero lash)		9.83 (.387)
	Outer spring press. & length	Valve closed — N at mm (lb. at in.)	284-320 @ 32 (64-72 @ 1.26)
		Valve open — N at mm (lb. at in.)	743-797 @ 22.5 (167-179 @ .886)
	Inner spring press. & length	Valve closed — N at mm (lb. at in.)	NONE
		Valve open — N at mm (lb. at in.)	NONE

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Engine — Lubrication System

Type of lubrication (splash, pressure, nozzle)	Main bearings	PRESSURE
	Connecting rods	PRESSURE
	Piston pins	SPLASH
	Camshaft bearings	PRESSURE
	Tappets	PRESSURE
	Timing gear or chain	NONE
	Cylinder walls	SPLASH
Oil pump type		GEAR
Normal oil pressure-kPa (psi) at engine rpm		379 (55)
Type oil intake (floating, stationary)		STATIONARY
Oil filter system (full flow, part. other)		FULL FLOW
Capacity of c/case, less filter-refill-L (qt.)		3.8 (4.0)
Oil grade recommended (SAE viscosity and temperature range)		
MINUS 6.6°C(20°F)& ABOVE		20W-20,10W-30,10W-40,20W-40,20W-50
MINUS 17.7°Cto+15.5°C (0 to 60°F)		10W,5W-30,10W-30,10W-40
MINUS 6.6°C(20°F)& BELOW		5W-20,10W-30
Engine service reqmt. (SD, SE, etc.)		SE

Engine — Exhaust System

Type (single, single with cross-over, dual, other)		SINGLE
Muffler No. & Type (reverse flow, straight thru, separate resonator)		ONE, REVERSE FLOW
Resonator No. & type		ONE, STRAIGHT THRU (a)
Exhaust Pipe	Branch O.D., wall thickness	---
	Main O.D., wall thickness	44.45 (1.75)
	Material	STAINLESS STEEL TUBING
Intermediate Pipe	O.D. & wall thickness	50.8 (2.0)
	Material	ALUMINUM COATED STEEL
Tail Pipe	O.D. & wall thickness	44.45 (1.75)
	Material	ALUMINUM STEEL TUBING

(a) CALIFORNIA ONLY.

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Car Line: CHEVETTE
Model Year: 1980 Issued: 9-80 Revised (•) ______

Engine Description / Carb. Engine Code	1.6 LITER L-4 (98 CID) 2-BBL CARBURETOR RPO L17

Engine — Fuel System

(See supplemental page for Details of Fuel Injection, Supercharger, Turbocharger, etc. if used)

Induction type: Carburetor, fuel injection system, etc.			CARBURETOR
Fuel Tank	Refill capacity — L (U.S. gals.)		47.3 (12.5) APPROXIMATELY
	Filler location		LEFT REAR QUARTER PANEL
Fuel Pump	Type (elec. or mech.)		MECHANICAL
	Locations ON ENGINE		LOWER LF
	Pressure range — kPa (psi)		34-45 (5.0-6.5)
Fuel Filter	Type		FINE MESH PLASTIC STRAINER IN GASOLINE TANK &
	Locations		PAPER FILTER ELEMENT IN CARBURETOR INLET
Carburetor	Choke type		ELECTRIC
	Intake manifold heat control (exhaust or water)		EXHAUST
	Air cleaner type	Standard	REPLACEABLE PAPER ELEMENT, SINGLE SNORKEL
		Optional	
	Idle spd.-rpm (spec. neutral or drive)	Manual	800 (700 with 3.36:1 axle)
		Propane (Neu.)	
		Automatic	700
		Propane (Neu.)	
	Idle A/F mix.		

Carburetor Supplementary Information

Model Usage	Engine Displ. — L (in.^{3})	Transmission	[illegible] Make	[illegible] Model	No. Used and Type (Barrels)	Barrel Size
ALL	1.6 (98)	MANUAL	Holley	[illegible] ([illegible])	One 2-BBL	PRI-32(1.26)
		AUTOMATIC		[illegible] ([illegible])		SEC-36(1.417)

Engine — Diesel Information

Glow plug		
Injector nozzle	Type	
	Opening pressure—kPa. (psi)	
Pre-Chamber design		
Fuel injection pump	Manufacturer	
	Type	
Supplementary vacuum source (type)		

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Engine Description/Carb. Engine Code	1.6 LITER L-4 (98 CID) 2-BBL CARBURETOR RPO L17

Engine — Cooling System

Coolant recovery system (std., opt., none)			STANDARD
Radiator cap relief valve pressure — kPa (psi)			103.4 (15.0)
Circulation thermostat	Type (choke, bypass)		CHOKE
	Starts to open at °C (°F)		88 (190)
Water pump	Type (centrifugal, other)		CENTRIFUGAL
	GPM 1000 pump rpm		
	Number of pumps		ONE
	Drive (V-belt, other)		V-BELT
	Bearing Type		DOUBLE ROW BALL
By-pass recirculation type (inter., ext.)			INTERNAL
Radiator core type (cross-flow) vertical, cellular, tube and fin, other)			CROSSFLOW, TUBE & CENTER
Cooling System Capacity	With heater — L(qt.) (*)		8.67 (9.16)
	Without heater — L(qt.)		HEATER STANDARD EQUIPMENT
	(@) Opt equipment-specify — L (qt.)		8.76 (9.26)
Water jackets full length of cyl. (yes, no)			YES
Water all around cylinder (yes, no)			YES
Radiator hose	Lower	Number and type (molded, straight)	ONE, MOLDED
		Inside diameter	
	Upper	Number and type (molded, straight)	ONE, MOLDED
		Inside diameter	
	By-pass	Number and type (molded, straight)	NONE
		Inside diameter	
Radiator (Core)	Standard	Width	
		Height	
		Thickness	
	A/C	Width	426.7 (16.8)
		Height	375.2 (14.8)
		Thickness	31.5 (1.24)
	Heavy duty	Width	426.7 (16.8)
		Height	375.2 (14.8)
		Thickness	31.5 (1.24)
Fan (Standard)	Number of blades & type - Flex/Solid		4, STAGGERED
	Diameter		330 (13.0)
	Ratio — fan to crankshaft rev		
	Fan cutout type		NONE
	Drive Type-Number of Fans		V-BELT - ONE
Fan (optional)	No. of blades and spacing		7, STAGGERED
	Diameter		360 (14.17)
	Ratio — fan to crankshaft rev.		
	Fan cut-out type		CLUTCH
	Drive Type-Number of Fans		V-BELT - ONE

(*) BASE TRANSMISSION
(@) WITH AIR CONDITIONING

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Engine Description/Carb. Engine Code	1.6 LITER L-4 (98) 2-BBL. CARB. RPO L17

Vehicle Emission Control

Exhaust Emission Control	Type (Air injection, engine modifications, other)			AIR INJECTION W/COMPUTER COMMAND CONTROL
	Air Injection Pump	Type		
		Displacement — cm^3 (in^3)		
		Drive ratio		
		Drive type		
		Relief valve (type)		
		Filter (describe)		
	Air Injection System	Air distribution (head, manifold, etc.)		
		Point of entry		
		Injection tube i.d.		
		Check valve type		
		Backfire protection (type)		
	Exhaust Gas Recirculation System	Type (controlled flow, open orifice, other)		CONTROLLED FLOW
		Valve type		VACUUM MODULATED SHUT-OFF & METERING
		Valve location		INLET MANIFOLD
		Control energy source		CARBURETOR VACUUM
		Exhaust source		MANIFOLD
		Exhaust cooler type		NONE
		Orifice no. and size		ONE
		Point of exhaust injection (spacer, carburetor, manifold, other)		INLET MANIFOLD
	Catalytic Converter System	Catalyst	Type	PLATINUM-PALLADIUM
			Volume — L (in^3)	2.622 (160)
		Substrate type		SINGLE BED
		Container location		BENEATH RF UNDERBODY
	Other	CARBURETOR HOT AIR		THERMOSTATICALLY CONTROLLED AIR CLEANER REGULATES AND MIXES HEATED AIR WITH INCOMING COLD AIR TO REDUCE HYDROCARBON EMISSION.

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Engine Description/Carb.
Engine Code

1.6 LITER L-4 (98 CID)
2-BBL CARBURETOR
RPO L17

Vehicle Emission Control (Continued)

Crankcase Emission Control	Type (ventilates to atmos., induction system, other)		Standard	INDUCTION SYSTEM
			Optional	
	Control Unit	Make and model		A.C.
		Location		VALVE ROCKER COVER
		Energy source (manifold vacuum, carburetor, other)		MANIFOLD VACUUM
		Control method (variable orifice, fixed orifice, other)		VARIABLE ORIFICE
	Complete System	Discharges (to intake manifold, other)		INLET MANIFOLD
		Air inlet (breather cap, other)		CARBURETOR AIR CLEANER
		Flame arrestor (screen, other)		SCREEN
Evaporative Emission Control	Fuel Tank	Thermal expansion volume — dm^3 (ft^3)		
		Relief Pressure kPa (psi) and location		
		Vacuum relief kPa (psi) and location		
		Vapor-liquid separator type		INTEGRAL WITH FUEL TANK
		Vapor vented to (crankcase, canister, other)		CANISTER
	Carbu-etor	Vapor vented to (crankcase, canister, other)		
	Vapor Storage	Storage provision (crankcase, canister, other)		CANISTER
		Volume — dm^3 (ft^3) or capacity (grams)		APPROX. 30 GRAMS
		Control valve type		VACUUM DIAPHRAGM CONTROLLED CONSTANT ORIFICE

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Electrical — Supply System

Battery	Make and Model		DELCO 'FREEDOM II'
	Voltage Rtg. — V — & Total Plates		12V
	SAE Designation No. and/or capacity		58 MIN. RES. CAP. (M/T) 75 MIN. RES. CAP. (A/T)
	Location		ENGINE COMPARTMENT, R.F.
Generator or Alternator	Make		DELCO REMY
	Model		1100138
	Type and rating		42
	Output at engine idle (neutral) A		
	Ratio — Gen. to Cr/s rev.		
Regulator	Make		DELCO REMY
	Model		
	Type		MICRO CIRCUIT UNIT; INTEGRAL WITH DISTRIBUTOR
	Regulated	Voltage	
		Current A	
	Voltage test conditions	Temperature — °C (°F)	
		Load A	
		Other	

Electrical — Starting System

Starting Motor	Make			DELCO REMY
	Model			
Motor Drive	Engagement Type			POSITIVE SHIFT SOLENOID
	Pinion engages from (front, rear)			REAR
	Number of teeth	Pinion		9
		Flywheel	Manual	153
			Auto	153

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Engine Description/Carb. Engine Code	1.6 LITER L-4 (98 CID) 2-BBL CARBURETOR RPC LI7

Electrical — Ignition System — Distributor

Distributor	Manual	1110580
	Automatic	1110580
Timing	Manual	18° BTC
	Automatic	18° BTC

Distributor Model	CENTRIFUGAL ADVANCE Crankshaft Degrees at Engine RPM			VACUUM ADVANCE Crankshaft Deg. at kPa (in. of Hg.)	
	Start	Intermediate	Maximum	Start	Maximum
1110580	DOES NOT APPLY				

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Electrical — Ignition System

Type	Conventional — Std., Opt., N.A.		---
	Transistorized — Std., Opt., N.A.		---
	Other (specify)		HIGH ENERGY IGNITION (HEI)
Coil	Make		DELCO REMY
	Model		MOUNTED TO CASE
	Current	Engine stopped — A	
		Engine idling — A	
Spark Plug	Make		A.C.
	Model		R42TS
	Thread (mm)		14
	Tightening torque — N·m (lb. ft.)		
	Gap		0.889 (.035)

Electrical — Suppression

Locations & type	

Electrical — Instruments and Equipment

Speedometer	Type	CIRCULAR DIAL WITH POINTER
	Trip odometer (std., opt., N.A.)	NA
EGR maintenance indicator		NA
Charge Indicator	Type	TELL-TALE
	Warning device	NA
Temperature Indicator	Type	TELL-TALE
	Warning device	NA
Oil pressure Indicator	Type	TELL-TALE
	Warning device	NA
Fuel Indicator	Type	ELECTRIC GAUGE
	Warning device	NA
Windshield Wiper	Type — standard	ELECTRIC 2-SPEED
	Type — optional	INTERMITTENT WINDSHIELD WIPER SYSTEM
	Blade length	403.4 (15.9 IN)
	Swept area — cm²(in.²)	3951 (612.5 IN²)
Windshield Washer	Type — standard	PUSH-BUTTON
	Type — optional	NONE
	Fluid level indicator	NA
Horn	Type	VIBRATOR
	Number used	ONE
Other	CURRENT DRAW (A) PER HORN	4.5-6.0 @ 12.5 VOLTS PARKING BRAKE WARNING LIGHT AND BRAKE FAILURE WARNING LIGHT, RESTRAINT SYSTEM WARNING LIGHT AND BUZZER.

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Drive Units — Clutch (Manual Transmission)

Make & type		BORG & BECK, DIAPHRAGM
Type pressure plate springs		
Total spring load — N (lb.)		
No. of clutch driven discs		ONE
Clutch facing	Material	MOLDED TYPE ASBESTOS
	Manufacturer	BORG & BECK
	Part Number	
	Rivets/Plate	16
	Rivet size	3.63 x 5.41 (.143 x .213)
	Outside & inside dia.	180 x 131 (8.0 x 5.16)
	Total eff. area-cm^2 (in.^{2})	239.5 (37.14)
	Thickness	3.35-3.51 (.135-.145)
	Engagement Cushion method	FLAT SPRING STEEL BETWEEN FACINGS
Release bearing	Type & method of lubrication	SINGLE ROW BALL, PACKED & SEALED
Torsional damping	Method: springs, friction material	COIL SPRINGS

Drive Units — Transmissions

Manual 3-speed (std., opt., N.A.)	N.A.
Manual 4-speed (std., opt., N.A.)	BASE
Manual 5-speed (std., opt., N.A.)	N.A.
Manual overdrive (std., opt., N.A.)	N.A.
Automatic (std., opt., N.A.)	AVAILABLE
Automatic overdrive (std., opt., N.A.)	N.A.

Drive Units — Manual Transmission

Number of forward speeds			4
Transmission ratios	In first		3.75
	In second		2.16
	In third		1.38
	In fourth		1.00
	In fifth		---
	In overdrive		---
	In reverse		3.82
Synchronous meshing, specify gears			ALL FORWARD GEARS
Shift lever location			FLOOR MOUNTED
Lubricant	Capacity — L (pt.)		1.6 (3.4)
	Type recommended		GL-5 GEAR LUBRICANT
	SAE viscosity number	Summer	80W or 80W-90
		Winter	80W or 80W-90
		Extreme cold	80W or 80W-90

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Drive Units — Automatic Transmission

Trade name		3-SPEED AUTOMATIC	
Type (describe)		TORQUE CONVERTER WITH PLANETARY GEARS	
Selector	Location	'180c'	'200c'
	Ltr./No. Designation	FLOOR MOUNTED	
Gear Ratios	R	P-R-N-D-2-1	
	D	1.92	2.07
	L_3	1.00	1.00
	L_2	1.48	1.57
	L_1	2.40	2.74
Max. upshift speed — drive range — km/h (mph)			
Max. kickdown speed-drive range — km/h (mph)			
Min. overdrive speed — km/h (mph)		---	
Torque Converter	Number of elements	3	
	Max. ratio at stall	2.25	
	Type of cooling (air, liquid)	LIQUID	
	Nominal diameter	245 (9.65)	
Lubricant	Capacity — refill — L (pt.)	2.8 (6.0)	
	Type recommended	DEXRON II	
Special transmission features		TORQUE CONVERTER CLUTCH, 3RD GEAR LOCK-UP	

Drive Units — Axle or Front Wheel Drive Unit

Type (front, rear)			REAR
Description			SEMI-FLOATING WITH HYPOID OVERHUNG PINION GEAR
Limited Slip differential, type			NOT AVAILABLE
Drive Pinion Offset			28.4 (1.12)
Drive pinion type			HYPOID GEAR
No. of differential pinions			TWO
Pinion adjustment (shim, other)			SHIMS
Pinion bearing adj. (shim, other)			COLLAPSIBLE SLEEVE
Driving wheel bearing type			DIRECT SINGLE ROW BALL
Lubricant	Capacity — L (pt.)		0.8 (1.75)
	Type recommended		GL-5 GEAR LUBRICANT
	SAE viscosity number	Summer	80W or 80W-90
		Winter	80W or 80W-90
		Extreme cold	80W or 80W-90

Axle or Transaxle Ratio and Tooth Combinations (See "Power Teams" for axle ratio usage.)

Axle Ratio or Overall Ratio (:1)		3.70
No. of teeth	Pinion	10
	Ring gear or gear	37
Ring Gear O. D.		165 (6.50)
Transaxle	Transfer Gear Ratio	
	Final Drive Ratio	

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Engine Description/Carb. Engine Code			2-DOOR COUPE	4-DOOR SEDAN

Drive Units — Propeller Shaft — Conventional Drive

			2-DOOR COUPE	4-DOOR SEDAN
Type (straight tube, tube-in-tube, internal-external damper, etc.)			(a)	
Outer diam. x length* x wall thickness	Manual 3-speed trans.		N.A.	
	Manual 4-speed trans.		50.8 x 731.5 x 1.40 (2.0 x 28.8 x .055)	50.8 x 808.2 x 1.40 (2.0 x 31.8 x .055)
	Manual 5-speed trans.		N.A.	
	Overdrive		N.A.	
	Automatic transmission (b)		50.8 x 586.0 x 1.40 (2.0 x 23.1 x .055)	50.8 x 662.2 x 1.40 (2.0 x 26.1 x .055)
Intermediate bearing	Type (plain, anti-friction)		ANTI-FRICTION	
	Lubrication (fitting prepack)		PREPACK	
Slip Yoke	Type		SPLINE	
	Number of teeth		27	
	Spline O.D.		28 (1.12)	
Universal joints	Make and Mfg. No.	Front	SAGINAW 23	
		Rear		
	Number used		TWO	
	Type (ball and trunnion, cross)		CROSS	
	Rear attach (u-bolt, clamp, etc.)		U-BOLT	
	Bearing	Type (plain, anti-friction)	ANTI-FRICTION	
		Lubric, (fitting, prepack)	PREPACK	
Drive taken through (torque tube or arms, springs)			ARMS	
Torque taken through (torque tube or arms, springs)			TORQUE TUBE	

*Center to center of universal joints, or to centerline of rear attachment.

(a) STRAIGHT TUBE ATTACHED TO 'U' JOINTS TO A SOLID STEEL PINION EXTENSION. A TORQUE TUBE HOUSING EXTENSION SHAFT IS BOLTED.

(b) TUNED TORSIONAL DAMPER USED WITH AUTOMATIC TRANSMISSION.

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Engine Description/Carb. Engine Code	2-DOOR HATCHBACK COUPE	4-DOOR HATCHBACK SEDAN

Drive Units — Tires And Wheels (Standard)

TIRES	Size, load range, ply		P155/80R13 (BW, WW)*
	Type (bias, radial, etc.)		GLASS BELTED RADIAL
	Inflation pressure (cold) for recommended max. vehicle load	Front-kPa (psi)	180 (26)
		Rear-kPa (psi)	180 (26)
	Rev./mile—at 70 km/h (45 mph)		569 (916)
WHEELS	Type & material		SHORT YOKE DISC, STEEL
	Rim (size & flange type)		13 x 5
	Wheel offset		37 mm
	Attachment	Type (bolt or stud)	STUD
		Circle diameter	100 mm
		Number & size	4 HEX NUTS - M12 x 1.5
Spare tire and wheel (same or other)			WHEEL- 14 x 4 (49 mm); COMPACT TIRE - T115/70D14

Drive Units — Tires And Wheels (Optional)

Size, load range, ply	P175/70R13 (BW, WW, WL)
Type (bias, radial, etc.)	STEEL BELTED RADIAL
Wheel type & material	
Rim (size, flange type, and offset)	
Size, load range, ply	
Type (bias, radial, etc.)	
Wheel type & material	
Rim (size, flange type, and offset)	
Size, load range, ply	
Type (bias, radial, etc.)	
Wheel type & material	
Rim (size, flange type, and offset)	
Size, load range, ply	
Type (bias, radial, etc.)	
Wheel type & material	
Rim (size, flange type, and offset)	
Spare tire and wheel (if configuration is different than road tire or wheel, describe optional spare tire and/or wheel)	

Brakes — Parking

Type of control		GRIP HANDLE
Location of control		ON FLOOR BETWEEN SEATS
Operates on		REAR SERVICE BRAKES
If separate from service brakes	Type (internal or external)	---
	Drum diameter	---
	Lining size (length x width x thickness)	---

(*) BLACKWALL STANDARD ON MODEL 1TJ08; WHITE WALL STANDARD ON MODEL 1TB00.

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Body Type And/Or Engine Displacement

2-DOOR COUPE	4-DOOR SEDAN

Brakes — Service

Brake Type (std., Opt., N.A.)	Drum	Front		N.A.
		Rear		STD.
	Disc	Front		STD.
		Rear		N.A.
Self-adjusting (std., opt., N.A.)				STD.
Special Valving	Type (proportion, delay, metering, other)			PROPORTIONING
Power Brake (std., opt., N.A.)				OPT.
Booster Type (remote, integral, vac., hyd., etc.)				INTEGRAL
Anti-skid device type (std., opt., N.A.)				N.A.
Effective area — cm^2 ($in.^2$)*				514.9 (79.83)
Gross lining area — cm^2 ($in.^2$)**				
Swept area — cm^2 ($in.^2$)***				1804.5 (279.77)
Rotor	Outer working diameter		F	246 (9.68)
			R	---
	Inner working diameter		F	143.8 (5.66)
			R	---
	Thickness		F	11 (.433)
			R	---
	Material & type (vented/solid)		F	CAST IRON, SOLID
			R	---
Drum	Diameter (nominal)		F	---
			R	200 (7.87)
	Type and material			DUO-SERVO; CAST IRON
Wheel cylinder bore	Front			47.62 (1.88)
	Rear			17.5 (0.69)
Master Cylinder	Bore			19 (0.75)
	Stroke			31 (1.22)
Pedal arc ratio				5.8:1 MANUAL; 4.75:1 POWER
Line pressure at 445 N (100 lb.) pedal load—MPa (psi)				
Lining Clearance Per Shoe	Front			SELF ADJUSTING
	Rear			SELF ADJUSTING
Brake lining	Front Wheel	Bonded or riveted, rivets/seg.		BONDED
		Rivet size		---
		Manufacturer		DELCO MORAINE
		Lining Code		
		Material		INNER-ORGANIC; OUTER-METALLIC
		**** Size	Prim. or out-board	114 x 34 x 9.40 (4.49 x 1.34 x .370)
			Second or In-board	114 x 30 x 9.40 (4.49 x 1.18 x .370)
		Shoe thickness (no lining)		
	Rear Wheel	Bonded or riveted, rivets/seg.		RIVETED
		Manufacturer		DELCO MORAINE
		Lining Code		
		Material		ORGANIC
		**** Size	Prim. or out-board	167.7 x 43.9 x 3.8 (6.6 x 1.73 x 0.15)
			Second or in-board	203.3 x 43.9 x 4.8 (8.0 x 1.73 x 0.19)
		Shoe thickness (no lining)		2.75 (.106)

*Excludes rivet holes, grooves, chamfers, etc.

**Includes rivet holes, grooves, chamfers, etc.

***Total swept area for four brakes. (Drum brake: Widest lining contact width for each brake x its contact circumference.) (Disc brake: Square of Outer Worki Dia. minus Square of Inner Working Dia. multiplied by Pi/2 for each brake.)

****Size for drum brakes includes length x width x thickness.

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Steering

				2-DOOR COUPE / 4-DOOR SEDAN
Manual (std., opt., N.A.)				STD.
Power (std., opt., N.A.)				OPT. (a)
Adjustable steering wheel (tilt, swing, other)	Type and description			TILT-UNIVERSALLY JOINTED STEERING SHAFT AT BASE OF STEERING WHEEL
	(Std., opt., N.A.)			OPT.
Wheel diameter	Manual			381 (15.0)
	Power			381 (15.0)
Turning diameter m (feet)	Outside front	Wall to wall (l. & r.)		
		Curb to curb (l. & r.)		
	Inside rear	Wall to wall (l. & r.)		
		Curb to curb (l. & r.)		
Manual	Gear	Type		RACK & PINION
		Make		SAGINAW STEERING GEAR
		Ratios	Gear	19.0:1
			Overall	18.4:1
	No. wheel turns (stop to stop)			3.6
Power	Type (coaxial, linkage, etc.)			
	Make			SAGINAW STEERING GEAR
	Gear	Type		RACK & PINION WITH INTEGRAL POWER UNIT
		Ratios	Gear	
			Overall	18.0:1
	Pump driven by			'V' BELT
	No. wheel turns (stop to stop)			
Linkage	Type			PARALLELOGRAM
	Location (front or rear of wheels, other)			FRONT
	Drag links (trans. or longit.)			NONE
	Tie rods (one or two)			TWO
Steering Axis	Inclination at camber (deg.)			7.55
	Bearings (type)	Upper		BALL STUD
		Lower		BALL STUD
		Thrust		NONE
Steering spindle & joint type				FORGED KNUCKLE w/UPPER & LOWER SPHERICAL JOINTS
Wheel Spindle	Diameter	Inner bearing		26.97 (1.06)
		Outer bearing		17.45 (0.69)
	Thread size			3/4 - 20 NEF (MIG-1)
	Bearing type			TAPERED ROLLER
Wheel Align at curb mass (wt.)	Service checking	Caster (deg.)		
		Camber (deg.)		
		Toe-in [outside track-mm (in.)]		
	Service reset	Caster		
		Camber		
		Toe-in		
	Periodic M V Inspection	Caster		
		Camber		
		Toe-in		

(a) AVAILABLE ONLY WITH AUTOMATIC TRANSMISSION AND AIR CONDITIONING.

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Body Type And/Or Engine Displacement

		2-DOOR COUPE	4-DOOR SEDAN

Suspension — General

Car leveling	Standard/Optional/NA	N.A.
	Type (air, hyd., etc.)	---
	Manual/auto. controlled	---
Provision for brake dip control		FRONT SUSPENSION GEOMETRY
Provision for acc. squat control		REAR SUSPENSION GEOMETRY
Special provisions for car jacking		POSITION JACK IN BUMPER SLOTS IN BOTTOM OF FRONT & REAR BUMPER FACE BARS
Shock absorber front & rear	Type	DIRECT, DOUBLE ACTING, HYDRAULIC
	Make	DELCO
	Piston dia.	25 (1.0)
Other special features		

Suspension — Front

Type and description		INDEPENDENT SLA
Travel	Full Jounce	
	Full Rebound	
Spring	Type (coil, leaf, other)	COIL
	Material	STEEL ALLOY
	Size (coil design height & I.D., bar length x dia.)	209.3(8.24) x 81.7 (3.22) x 2690.8 (105.9) x 12.06 (0.475)
	Spring rate — N/mm (lb./in.)	28 (160)
	Rate at wheel — N/mm (lb./in.)	12.9 (74)
Stabilizer	Type (link, linkless, frameless)	LINK, MOUNTED TO BODY FRONT RAILS
	Material & bar diameter	HR STEEL - 22 (.87); RPO F41 SPT. SUSP.-25 (1.0)

Suspension — Rear

Type and description			SOLID AXLE, POSITIONED BY LINKS, TORQUE TUBE & TRACK BAR
Drive and torque taken through			LINK, TORQUE TUBE
Travel	Full Jounce		
	Full Rebound		
Spring	Type (coil, leaf, other)		COIL
	Material		STEEL ALLOY
	Size (length x width, coil design height & I.D., bar length & dia.)		233.7(9.20) x 92.62(3.65) x 2301.9(90.6) x 13.19(0.519)
	Spring rate — N/mm (lb./in.)		27.1 (155)
	Rate at wheel — N/mm (lb./in.)		20.5 (117)
	Mounting insulation type		
	If leaf	No. of leaves	---
		Shackle (comp. or tens.)	---
Stabilizer	Type (link, linkless, frameless)		LINK, MOUNTED TO UNDERBODY (RPO F41 SPT. SUSP. ONLY)
	Material & bar diameter		HR STEEL - 16 (0.63)
Track bar type			TUBULAR, WITH RUBBER BUSHINGS

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Body Type

2-DOOR HATCHBACK COUPES		4-DOOR HATCHBACK SEDAN
1TB08	1TJ08	1TB68

Body — Miscellaneous Information

Type of finish (lacquer, enamel, other)		LACQUER
Hood hinge location (front, rear)		REAR
Hood counterbalance (type)		HOOD IS NOT COUNTERBALANCED. HOOD IS HELD OPEN WITH A ROD.
Hood release control (internal, external)		INTERNAL
Vehicle Ident. No. Location		TOP LEFT HAND OF INSTRUMENT PANEL PAD
Vent window control method (crank, friction pivot, power)	Front	NONE
	Rear	NONE
Seat cushion type	Front	FORMED FOAM PAD
	Rear	FORMED FOAM PAD
	3rd Seat	NONE
Seat back type	Front	FORMED FOAM PAD
	Rear	FORMED FOAM PAD
	3rd Seat	NONE
Method of holding luggage compart. lid open		TELESCOPING GAS STRUT - LEFT SIDE
Position of spare tire storage		FLAT UNDER REAR LOAD FLOOR

Passive Restraint System

Inflatable Restraint System	Standard/ Optional	
	Type of charging system	
	Location (stg. whl., instru. panel, other)	
Passive Seat Belts	Standard/ Optional	
	Power/ Manual	
	2 or 3 point	
	Knee bar/ Lap belt	

Frame

Type and description (Separate frame, unitized frame, partially-unitized frame)	UNITIZED FRAME WITH CROSSMEMBER REINFORCEMENT

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Body Type	2-DOOR HATCHBACK COUPES		4-DOOR HATCHBACK SEDAN
	1TB08	1TJ08	

Convenience Equipment

Power windows — Side Windows	N.A.		
Power windows — Vent Windows	N.A.		
Power windows — Backlight or tailgate	N.A.		
Power seats (specify type as well as availability)	N.A.		
Reclining front seat back (R-L or both)	STANDARD ON 1TB00 MODELS		
Radios (specify type as well as availability)	AM-PUSH-BUTTON, STANDARD EQUIPMENT 1TB00 MODELS, OPTIONAL 1TJ08. OPTIONAL-AM/FM PUSH-BUTTON, AM/FM PUSH-BUTTON STEREO.		
Rear seat speaker	OPTIONAL	N.A.	OPTIONAL
Power antenna	N.A.		
Clock	OPTIONAL		
Air Conditioner (specify type)	OPTIONAL-"FOUR SEASON" WITH MANUAL CONTROL		
Speed warning device	N.A.		
Speed control device	N.A.		
Ignition lock lamp	N.A.		
Dome lamp	STANDARD		
Glove compartment lamp	OPTIONAL 1TB00 MODELS, NOT AVAILABLE 1TJ08		
Luggage compartment lamp	OPTIONAL		
Underhood lamp	OPTIONAL		
Courtesy lamp	OPTIONAL		
Map lamp	N.A.		
Cornering lamp	N.A.		
Rear window defroster electrically heated	OPTIONAL		
Rear window defogger	N.A.		
Theft protection — type	LOCK; MOUNTED ON STEERING COLUMN; LOCKS STEERING WHEEL, TRANSMISSION SHIFT LEVER AND IGNITION.		

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Vehicle Mass (Weight)

Model		CURB MASS, kg. (Weight, lb.)*			% PASS MASS DISTRIBUTION				SHIPPING MASS, kg (Weight lb)**
		Front	Rear	Total	Pass. In Front		Pass In Rear		
					Front	Rear	Front	Rear	
2-DOOR HATCHBACK COUPE	1TB08	503.1 (1109)	430.3 (949)	933.4 (2058)	46.0	54.0	16.0	84.0	907.0 (2000)
2-DOOR HATCHBACK COUPE	1TJ08	479.5 (1057)	429.1 (946)	908.6 (2003)	46.0	54.0	16.0	84.0	882.2 (1945)
4-DOOR HATCHBACK SEDAN	1TB68	514.1 (1133)	448.3 (988)	962.4 (2122)	46.0	54.0	16.0	84.0	936.0 (2063)

CURB WEIGHT - THE CALCULATED WEIGHT OF A VEHICLE WITH STANDARD EQUIPMENT ONLY AS DESIGNED WITH THE ADDITIONAL LOAD OF OILS, LUBES, COOLANTS, AND FUEL FILLED TO CAPACITY.

SHIPPING WEIGHT - SAME AS BASE CURB WEIGHT EXCEPT 3 GALLONS OF GASOLINE.

*Reference — SAE J1100a, Motor Vehicle Dimensions, Curb Weight Definition.

**Shipping Mass (Weight) definition —

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Optional Equipment Differential Mass (Weight)*

Equipment	MASS, kg. (Weight, lb.) Front	Rear	Total	Remarks
Air Conditioning	29.4	6.2	35.6	4-Speed Transmission
	(+64.8)	(+13.6)	(+78.4)	
	28.6	6.2	34.8	Automatic Transmission
	(+63.0)	(+13.6)	(+76.6)	
Floor Mats Front & Rear	2.0	1.2	3.2	
	(+ 4.4)	(+2.6)	(+ 7.0)	
Power Brakes	2.6	0.4	3.0	
	(+ 6)	(+1)	(+7)	
Power Steering	10.0	0	10.0	
	(+22)	0	(+22)	
Deluxe Exterior	0.2	0	0.2	1TB00
	(+ 0.4)	0	(+ 0.4)	
Dual Sport Rear View Mirrors	0.8	0.4	1.2	1TB00
(L.H. Remote, Man Convex RH)	(+ 1.8)	(+0.8)	(+ 2.6)	
Molding-Body Side	0.4	0.6	1.0	1TJ08
	(+ 0.8)	(+1.4)	(+ 2.2)	
Sport Suspension	0.6	3.4	4.0	Available only with steel belted radial tires
	(+ 1.3)	(+7.5)	(+ 8.8)	
Heavy duty battery	2.0	-0.2	1.8	
	(+ 4.4)	(-0.4)	(+ 4.0)	
Heavy duty cooling	0.9	0.0	0.9	
	(+ 2.0)	0	(+ 2.0)	
Luggage Carrier	1.8	3.2	5.0	1TB & 1TJ08
(Roof Mounted)	(+ 4.0)	(+7.0)	(+11.0)	
	2.0	3.4	5.4	1TB68
	(+ 4.4)	(+7.4)	(+11.8)	
Washer ¢ Wiper - Rear	-0.4	2.4	2.0	
	(-0.8)	(+5.2)	(+ 4.4)	

*Also see Engine — General Section for dressed engine mass (weight).

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Optional Equipment Differential Mass (Weight)*

Equipment	MASS, kg. (Weight, lb.) Front	Rear	Total	Remarks
Comfortilt	1.4	0.4	1.8	
Steering Wheel	(+ 3.0)	(+0.8)	(+ 3.8)	
Radio AM Push-Button	1.6	0.4	2.0	
	(+ 3.6)	(+0.8)	(+ 4.4)	Standard Equipment 1TB00 Models,
				Optional 1TJ08
Radio AM/FM Push-Button	0.2	0	0.2	
	(+ 0.4)	0	(+ 0.4)	1TB00
	1.8	0.4	2.2	1TJ08
	(+ 4.0)	(+0.8)	(+ 4.8)	
Radio AM/FM Stereo	0.2	0	0.2	1TB00
(3-speakers)	(+ 0.4)	0	(+ 0.4)	
	1.8	0.4	2.2	1TJ08
	(+ 4.0)	(+0.8)	(+ 4.8)	
Auxiliary Speaker - Rear	0	0.6	0.6	
	(0)	(+1.4)	(+ 1.4)	
3-Speed Automatic	12.4	7.0	19.4	THM 180
Transmission	(+27.4)	(+15.4)	(+42.8)	1TB00
	13.2	7.6	20.8	1TJ08
	(+29.2)	(+16.8)	(+46.0)	
	10.0	5.8	15.8	THM 200
	(+22.0)	(+12.8)	(+34.8)	1TB00
	11.0	6.2	17.2	1TJ08
	(+24.2)	(+13.6)	(+37.8)	

*Also see Engine — General Section for dressed engine mass (weight).

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Car and Body Dimensions See Key Sheets for definitions

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All dimensions to ground are for comparative purposes only. Dimensions are to be shown for all base body models of each car line.
SAE Ref. No. refers to the definition published in SAE Recommended Practice.
J1100a "Motor Vehicle Dimensions," unless otherwise specified.

Body Type

	SAE Ref. No.	2-DOOR HATCHBACK COUPES 1TB08	2-DOOR HATCHBACK COUPES 1TJ08	4-DOOR HATCHBACK SEDAN 1TB68
Width				
Tread — Front	W101	1300 (51.2)		
Tread — Rear	W102	1300 (51.2)		
Vehicle width	W103	1570 (61.8)		
Body width at Sg RP — front	W117	1546 (60.9)		
Vehicle width — front doors open	W120	3384 (133.2)		3048 (120.0)
Vehicle width — rear doors open	W121	---		2974 (117.1)
Length				
Wheelbase	L101	2394 (94.3)		2471 (97.3)
Vehicle length	L103	4111 (161.9)		4188 (164.9)
Overhang — front	L104	787 (31.0)		
Overhang — rear	L105	930 (36.6)		
Upper structure length	L123	2510 (98.8)		2586 (101.8)
Rear wheel C/L "X" coordinate	L127	2179 (85.5)		
Cowl point "X" coordinate	L125	306 (12.0)		
Height **				
Passenger Distribution (frt./rear)	PD1, 2, 3	**		
Trunk/Cargo load		**		
Vehicle height	H101	1344(52.9)	1343(52.9)	1343 (52.9)
Cowl point to ground	H114	897(35.3)	896(35.3)	897 (35.3)
Deck point to ground	H138			
Rocker panel front to ground	H112	209(8.2)	208(8.2)	209 (8.2)
Bottom of door closed - front to grd.	H133	271(10.7)	270(10.6)	271 (10.7)
Rocker panel rear to ground	H111	204 (8.0)		
Bottom of door closed - rear to grd.	H135	---		
Ground Clearance **				
Front bumper to ground	H102	330 (13.0)		
Rear bumper to ground	H104	330 (13.0)		
Bumper to ground — front at curb mass (wt.)	H103	357 (14.1)		
Bumper to ground — rear at curb mass (wt.)	H105	349 (13.7)		
Angle of approach @ GVW	H106	19.0°	18.9°	19.0°
Angle of departure @ GVW	H107	19.5°		19.3°
Ramp breakover angle @ GVW	H147	18.2°		17.6°
Rear axle differential to ground	H153	270 (10.6)		
Min. running ground clearance	H156	147(5.8)(a)	146(5.7)(a)	147(5.8)(a)
Location of min. run. grd. clear.		(a) K-BRACE UNDER FRONT CROSSMEMBER		

All linear dimensions are in millimeters (inches) and all mass (weight) specifications are in kilograms (pounds).

** All vehicle height and ground clearances are made using EPA loaded vehicle weight, loading conditions.

EPA LOADED VEHICLE WEIGHT is the base vehicle weight plus all coolant and fluids necessary for operation plus 100% of the fuel capacity, plus the weight of all options and accessories which weigh three pounds or more and which are sold on at least 33% of the car line, plus two occupants.

[illegible] Specifications Form
[illegible] Car
[illegible] U.S. Customary)
[illegible] Dimensions See Key Sheets for definitions

Car Line CHEVETTE

Model Year 1981 Issued 9-80 Revised (•)

Body Type

	SAE Ref. No.	2-DOOR HATCHBACK COUPES 1TB08	2-DOOR HATCHBACK COUPES 1TJ08	4-DOOR HATCHBACK SEDAN 1TB68 •
[illegible] Compartment				
[illegible] coordinate	L31	1118 (44.0)		
[illegible]	H61	968 (38.1)		973 (38.3)
[illegible] head room	H75	974 (38.3)		978 (38.5)
[illegible] – accelerator	L34	1058(41.6)	1056(41.6)	1058 (41.6)
[illegible]	H30	259(10.2)	266(10.5)	259 (10.2)
[illegible] travel	L17	134 (5.3)		
[illegible]	W3	1273 (50.1)		1266 (49.8)
[illegible]	W5	1268 (49.9)		1256 (49.4)
** [illegible] to ground	H50			
[illegible] Angle	H18	30.2°		
[illegible]	L40	26.5°		
[illegible] Compartment				
[illegible] distance	L50	678 (26.7)		754 (29.7)
[illegible]	H63	947 (37.3)		949 (37.4)
[illegible] head room	H76	941 (37.0)		944 (37.2)
[illegible]	L51	785(30.9)	770(30.3)	860 (33.9)
[illegible] heel	H31	268 (10.5)		
[illegible]	L48	-62(-2.4)	-67(-2.6)	3.5 (0.1)
[illegible]	L3	569 (22.4)		644 (25.3)
[illegible]	W4	1254 (49.4)		1256 (49.4)
[illegible]	W6	1036 (40.8)		
** [illegible] to ground	H51	---		
[illegible] Compartment				
[illegible] capacity — L (cu. ft.)	V1	--		
** [illegible]	H195	753 (29.6)		756 (29.8)

[illegible] are in millimeters (inches).

** [illegible] VEHICLE WEIGHT, LOADING CONDITIONS

[illegible] DIMENSIONS ARE MEASURED WITH THE SEATING REFERENCE POINT (SgRP) FULL REAR AND ______ mm UPWARD [illegible] SEAT POSITION.

[illegible]

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)
Car and Body Dimensions See Key Sheets for definitions

Car Line CHEVETTE
Model Year 1981 Issued 9-80 Revised (•)

Body Type

SAE Ref. No.		2-DOOR HATCHBACK COUPES		4-DOOR HATCHBACK SEDAN
		1TB08	1TJ08	1TB68

Station Wagon — Third Seat

Shoulder room	W85	
Hip room	W86	
Effective leg room	L86	NOT
Effective head room	H86	APPLICABLE
Effective T Point head room	H89	
Seat facing direction	SD1	

Station Wagon — Cargo Space

Cargo length — open — front	L200	
Cargo length — open — second	L201	
Cargo length — closed — front	L202	NOT
Cargo length — closed — second	L203	APPLICABLE
Cargo length at belt — front	L204	
Cargo length at belt — second	L205	
Cargo width — wheelhouse	W201	
Rear opening width at floor	W203	
Opening width at belt	W204	
Max. rear opening width above belt	W205	
Cargo height	H201	
Rear opening height	H202	
Tail gate to ground height (Curb)	H250	
Front seat back to load floor height	H197	
Cargo volume index — m^3 ($ft.^3$)	V2	
Hidden cargo volume — m^3 ($ft.^3$)	V4	

Hatchback — Cargo Space

Front seat back to load floor height	H197	488 (19.2)	488 (19.2)
Cargo length at front seat Back Height	L208	1024 (40.3)	1100 (43.3)
Cargo length at floor — front	L209	1471 (57.9)	1547 (60.9)
Cargo volume index — m^3 ($ft.^3$)	V3	764L (27.0 cu.ft.)	811L (28.6 cu.ft.)
Hidden cargo volume — m^3 ($ft.^3$)	V4		

A printed or computer tape supplement containing additional car and body dimensions and/or drawings (based in part on SAE J1100a "Motor Vehicle Dimensions") may be available from the manufacturer.

All dimensions are in millimeters (inches).

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Car and Body Dimensions See Key Sheets for definitions

Car Line CHEVETTE

Model Year 1981 Issued 9-80 Revised (•)

Body Type

2-DOOR HATCHBACK COUPES		4-DOOR HATCHBACK SEDAN
1TB08	1TJ08	1TB68

Vehicle Fiducial Marks

Fiducial Mark Number *	Define Coordinate Location
Front	X - Fiducial mark to vertical base grid line-front, measured horizontally from the base grid line to the front fiducial mark located on top of the front seat adjuster mounting bolt. Y - Fiducial mark to centerline of car-front, width measurement made from centerline of car to fiducial mark located on top of the front seat adjuster mounting bolt. Z - Fiducial mark to horizontal base grid-front, measured vertically from base grid line to front fiducial mark located on top of the front seat adjuster mounting bolt.
Rear	X - Fiducial mark to vertical base grid line-rear measured horizontally from base grid line to the rear fiducial mark located on rear underbody crossbar. Y - Fiducial mark to centerline of car-rear, width measurement made from centerline of car to fiducial mark located on the rear underbody crossbar. Z - Fiducial mark to horizontal base grid line-rear, measured vertically from base grid line to the rear fiducial mark located on rear underbody crossbar.

Fiducial Mark Number		2-DOOR HATCHBACK COUPES	4-DOOR HATCHBACK SEDAN
Front	W21	504 (19.8)	
	L54	750 (29.5)	
	H81	150 (5.9)	
	H161	290 (11.4)	
**	H163	267 (10.5)	
Rear	W22	195 (7.7)	
	L55	2850 (112.2)	2926 (115.2)
	H82	278 (10.9)	
	H162	423 (16.7)	
**	H164	404 (15.9)	

*Reference — SAE Recommended Practice, J182a, A Motor Vehicle Fiducial Marks — September, 1973.
All linear dimensions are in millimeters (inches).

** EPA LOADED VEHICLE WEIGHT, LOADING CONDITIONS

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)
Car and Body Dimensions See Key Sheets for definitions

Car Line CHEVETTE
Model Year 1981 Issued 9-80 Revised (•)

Body Type

	SAE Ref. No.	2-DOOR HATCHBACK COUPES 1TB08	2-DOOR HATCHBACK COUPES 1TJ08	4-DOOR HATCHBACK SEDAN 1TB68
Glass				
Backlight slope angle	H121	62.5°		
Windshield slope angle	H122	52.8°		
Tumble-Home	W122	20.3°		
Windshield glass exposed surface area — cm^2 ($in.^2$)	S1	6735 (1043.9)		
Side glass exposed surface area — cm^2 ($in.^2$)	S2	9926 (1538.5)		10903 (1690.0)
Backlight glass exposed surface area — cm^2 ($in.^2$)	S3	5835 (904.4)		
Total glass exposed surface area — cm^2 ($in.^2$)	S4	22496(3486.9)		23473 (3638.3)
Windshield glass type		CURVED - LAMINATED PLATE		
Side glass type		CURVED - TEMPERED PLATE		
Backlight glass type		CURVED - TEMPERED PLATE		

Lamps and Headlamp Shape *

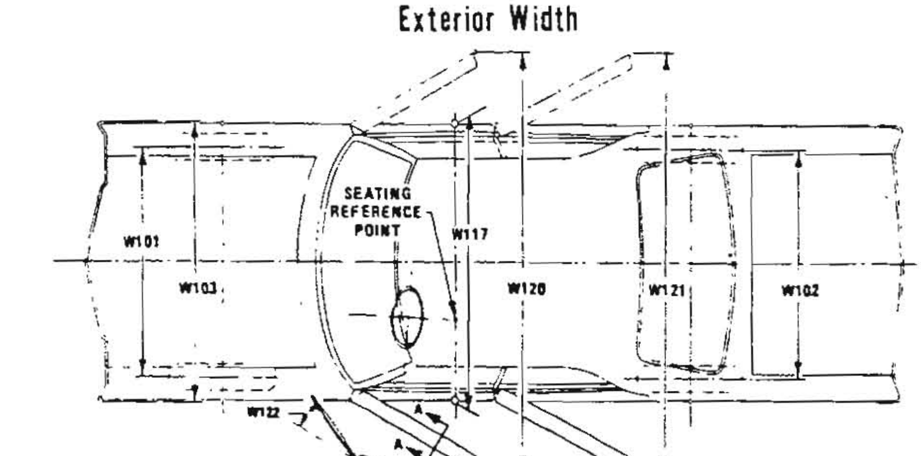
			1TB08	1TJ08	1TB68
Height above ground to center of bulb or marker	Headlamp (H127)	Highest **	642(25.3)	640(25.2)	642(25.3)
		Lowest	---		
	Tail (H128)	Highest	676(26.6)		
		Lowest	---		
	Sidemarker	Front	516(20.4)		
		Rear	676(26.6)		
Distance from C/L of car to center of bulb	Headlamp	Inside			
		Outside **			
	Tail	Inside			
		Outside			
	Directional	Front			
		Rear			
Headlamp Shape			RECTANGULAR		

* Measured at curb mass (weight).
** If single headlamps are used enter here

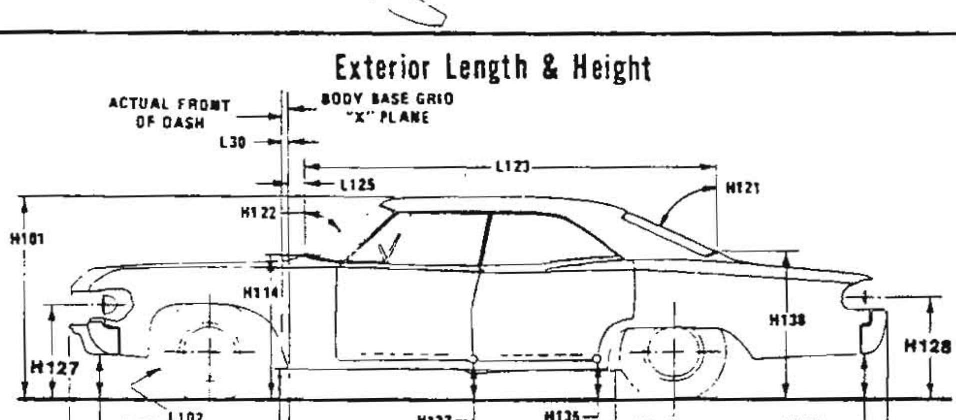
MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Exterior Car And Body Dimensions — Key Sheet

Exterior Width

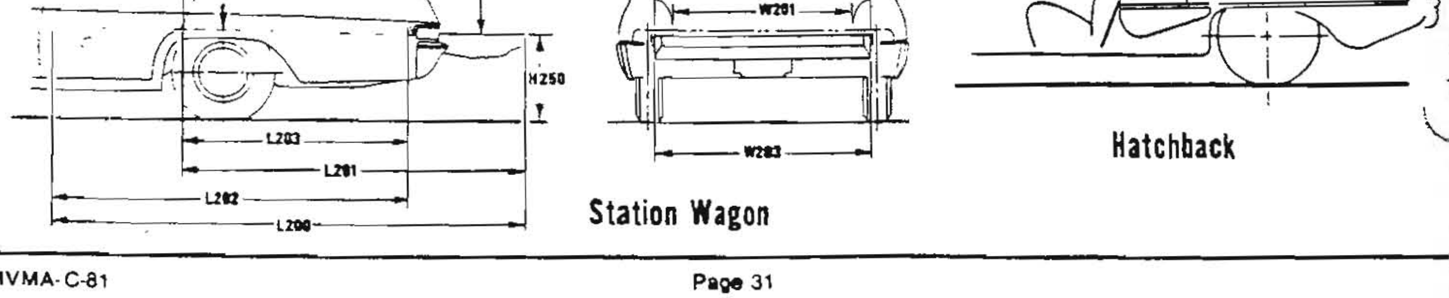


Exterior Length & Height



Exterior Ground Clearance

Cargo Space



Station Wagon

Hatchback

MVMA Specifications Form
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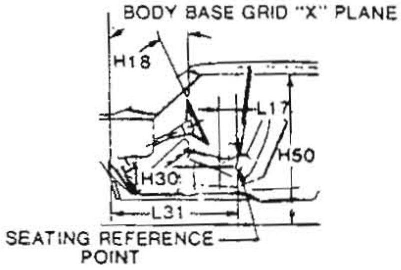
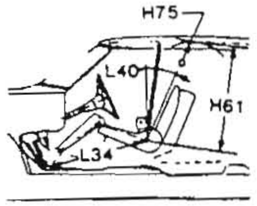
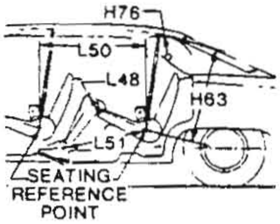
Interior Car And Body Dimensions — Key Sheet

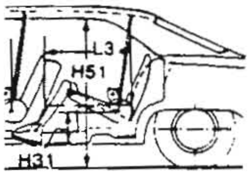
Front Compartment



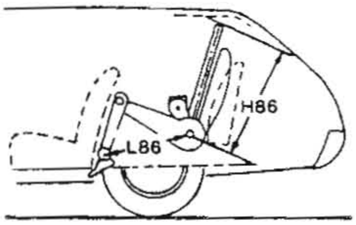


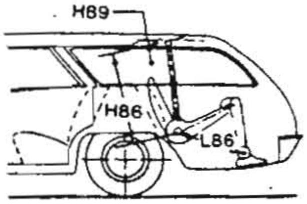
Rear Compartment

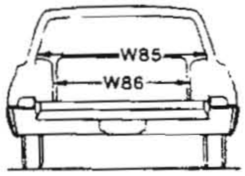




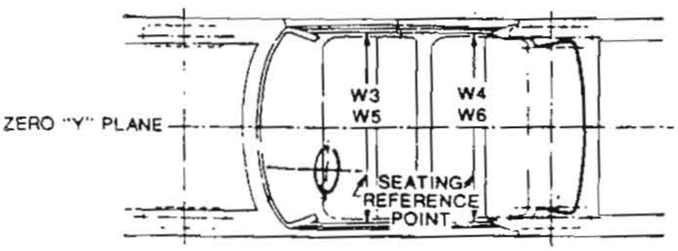
Third Seat







Interior Width



MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Exterior Car And Body Dimensions — Key Sheet
Dimensions Definitions

Seating Reference Point

SEATING REFERENCE POINT means the manufacturer's design reference point which —
(a) Establishes the rearmost normal design driving or riding position of each designated seating position in a vehicle;
(b) Has coordinates established relative to the design vehicle structure;
(c) Simulates the position of the pivot center of the human torso and thigh; and
(d) Is the reference point employed to position the two dimensional templates described in SAE Recommended Practice J826, "Manikins for Use in Defining Vehicle Seating Accommodations," November 1962.

Width Dimensions

W101 TREAD — FRONT. The dimension measured between the tire centerlines at the ground.

W102 TREAD — REAR. The dimension measured between the tire centerlines at the ground. In case of dual wheels, the dimension will be measured to the centerline of tire and wheel assemblies.

W103 VEHICLE WIDTH. The maximum dimension measured between the widest point on the vehicle, excluding exterior mirrors, flexible mud flaps, marker lamps, but including bumpers, moldings, sheet metal protrusions or dual wheels, if standard equipment.

W117 BODY WIDTH AT SgRP — FRONT. The dimension measured laterally between the widest points on the body at the SgRP - front, excluding door handles, applied moldings, or appliques.

W120 VEHICLE WIDTH — FRONT DOORS OPEN. The dimension measured between the widest point on the front doors in maximum hold-open position.

W121 VEHICLE WIDTH — REAR DOORS OPEN. The dimension measured between the widest point on the rear doors in maximum hold-open position. For vehicles with a rear door on only one side, this dimension is to the zero "Y" plane.

W122 TUMBLE HOME. STRAIGHT SIDE GLASS. The angle measured from a vertical to the outside surface of the front door glass at the SgRP "X" plane.
CURVED SIDE GLASS. The angle measured from a vertical to a chord extending from the upper DLO to the lower DLO at the outside surface of the front door glass at the front SgRP "X" plane.

Length Dimensions

L30 FRONT OF DASH "X" COORDINATE. A minus (−) dimension indicates actual front of dash is forward of the zero "X" plane.

L101 WHEELBASE (WB). The dimension measured longitudinally between front and rear wheel centerlines. In case of dual rear axles, the dimension shall be to the midpoint of the centerlines of the rear wheels.

L102 TIRE SIZE. As specified by the manufacturer.

L103 VEHICLE LENGTH. The maximum dimension measured longitudinally between the foremost point and the rearmost point on the vehicle, including bumper, bumper guards, two hooks and/or rub strips, if standard equipment.

L104 OVERHANG — FRONT. The dimension measured longitudinally from the centerline of the front wheels to the foremost point on the vehicle including bumper, bumper guards, two hooks and/or rub strips, if standard equipment.

L105 OVERHANG — REAR. The dimension measured longitudinally from the centerline of the rear wheels; or in the case of dual rear axles, the dimension shall be the midpoint of the centerlines of the rear wheels, to the rearmost point on the vehicle, including rear bumpers, bumper guards, two hooks and rub strips, if standard equipment.

L123 UPPER STRUCTURE LENGTH. The dimension measured longitudinally from the cowl point to the deck point.

L127 REAR WHEEL CENTERLINE "X" COORDINATE or in the case of dual rear axles, the coordinate shall be in the midpoint of the distance between the rear axle centerlines.

L125 COWL POINT "X" COORDINATE.

Height Dimensions

H101 VEHICLE HEIGHT. The dimension measured vertically from the highest point on the vehicle body to ground.

H114 COWL POINT TO GROUND. Measured at zero "Y" plane.

H138 DECK POINT TO GROUND. Measured at zero "Y" plane.

H112 ROCKER PANEL — FRONT TO GROUND. The dimension measured vertically from the foremost point on the bottom of the rocker panels, excluding flanges, to ground.

H132 BOTTOM OF DOOR OPEN — FRONT TO GROUND. The dimension measured vertically from the bottom outside corner of the door on the lock pillar side, in maximum hold-open position, to ground.

H111 ROCKER PANEL — REAR TO GROUND. The dimension measured vertically from the bottom of the rocker or side quarter panel at the front of the rear wheel opening, excluding flanges, to ground.

H134 BOTTOM OF DOOR OPEN — REAR TO GROUND. The dimension measured vertically from the bottom outside corner of the door on the lock pillar side, in maximum hold-open position, to ground.

H135 BOTTOM OF DOOR CLOSED — REAR TO GROUND. The dimension measured vertically from the bottom outside corner of the door on the lock pillar side, in maximum closed position, to ground.

H121 BACKLIGHT SLOPE ANGLE. The angle between the vertical reference line and the surface of backlight at vehicle zero "Y" plane. For curve backlight, the angle is to chord of backlight arc from lower DLO to upper DLO.

H122 WINDSHIELD SLOPE ANGLE. The angle between the vertical reference line and a chord of the windshield are running from the lower DLO to the upper DLO at the vehicle zero "Y" plane. In the case of wrap over glass, the angle to be measured will be formed by a chord 18.0 in. (457 mm) long, drawn from the lower DLO to the intersecting point on the windshield.

H127 HEADLAMP TO GROUND — CURB WEIGHT. The dimensional measured vertically from the centerline of the lowest headlamp lens to ground.

H128 TAILLAMP TO GROUND — CURB WEIGHT. The dimension measured vertically from the centerline of the upper bulb to ground.

Ground Clearance Dimensions

H102 FRONT BUMPER TO GROUND. The minimum dimension measured vertically from the lowest point on the front bumper to ground, including bumper guards, if standard equipment.

H103 FRONT BUMPER TO GROUND — CURB WEIGHT Measured in the same manner as H104

H104 REAR BUMPER TO GROUND The minimum dimension measured vertically from the lowest point on the rear bumper to ground, including bumper guards, if standard equipment

H105 REAR BUMPER TO GROUND — CURB WEIGHT. Measured in the same manner as H104.

H106 ANGLE OF APPROACH. The angle measured between a line tangent to the front tire static loaded radius are the initial point of structural interference forward of the front tire to ground. The limiting structural component shall be designated.

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Interior Car And Body Dimensions — Key Sheet Dimensions Definitions

H107 ANGLE OF DEPARTURE. The angle measured between a line tangent to the rear tire static loaded radius are the initial point of structural interference reaward of the rear tire to ground: The limiting component shall be designated.

H147 REAR BREAKOVER ANGLE. The angle measured between two lines tangent to the front and rear tire static loaded radius and intersecting at a point on the underside of the vehicle which defines the largest ramp over which the vehicle can roll.

H153 REAR AXLE DIFFERENTIAL TO GROUND. The minimum dimension measured from the rear axle differential to ground.

H156 MINIMUM RUNNING GROUND CLEARANCE. The minimum dimension measured from the sprung vehicle to ground. Specify location.

Front Compartment Dimensions

PD1 PASSENGER DISTRIBUTION — FRONT.

L31 SgRP — FRONT "X" COORDINATED

H61 EFFECTIVE HEAD ROOM — FRONT. The dimension measured along a line 8 deg. rear of vertical from the SgRP — front to the headline, plus 4.0 in (102 mm).

H75 EFFECTIVE T-POINT HEAD ROOM — FRONT. The minimum radius from the T-point to the headlining plus 30 in. (762 mm).

L34 MAXIMUM EFFECTIVE LEG ROOM — ACCELERATOR The dimension measured along a line from the ankle pivot center to the SgRP — front plus 10.0 in. (254 mm) measured with right foot on the undepressed accelerator pedal For vehicles with SgRP to heel (H30) greater than 18 in., the accelerator pedal may be depressed as specified by the manufacturer If the accelerator is depressed, the manufacturer shall place foot flat on pedal and note the depression of the pedal.

H30 SgRP — FRONT TO HEEL. The dimension measured vertically from the SgRP — front to the accelerator heel point

L17 DESIGN H-POINT — FRONT TRAVEL. The dimension measured horizontally between the design H-point — front in the foremost and rearmost seat trace positions

W3 SHOULDER ROOM — FRONT. The minimum dimension measured laterally between the trimmed surfaces on the "X" plane through the SgRP — front within the belt line and 10.0 in. (254 mm) above the SgRP — front.

W5 HIP ROOM — FRONT The minimum dimension measured laterally between the trimmed surfaces on the "X" plane through the SgRP — front within 1.0 in. (25mm) below and 3.0 (76 mm) above the SgRP — front and 3.0 (76 mm) fore and aft of the SgRP — front.

H150 UPPER BODY OPENING TO GROUND — FRONT. The dimension measured vertically from the trimmed body opening to the ground on the SgRP — front "X" plane.

H18 STEERING WHEEL ANGLE. The angle measured from a vertical to the surface plane of the steering wheel.

L40 BACK ANGLE — FRONT. The angle measured between a vertical line through the SgRP — front and the torso line. If the seatback is adjustable, use the normal driving and riding position specified by the manufacturer.

Rear Compartment Dimensions

PD2 PASSENGER DISTRIBUTION — SECOND.

L50 SgRP COUPLE DISTANCE. The dimension measured horizontally from the driver SgRP — front to the SgRP — second.

H63 EFFECTIVE HEAD ROOM — SECOND. The dimension measured along a line 8 deg. rear of vertical from the SgRP to the headlining, plus 4 0 in. (102 mm).

H76 EFFECTIVE T-POINT HEAD ROOM — SECOND. Measured in the same manner as H75.

L51 MINIMUM EFFECTIVE LEG ROOM — SECOND The dimension measured along a line from the ankle pivot center to the SgRP — second plus 10 0 in (254 mm)

H31 SgRP — SECOND TO HEEL. The dimension measured vertically from the SgRP — second to the two dimensional device heel point on the depressed floor covering.

L48 KNEE CLEARANCE — SECOND. The minimum dimension measured from the knee pivot to the back of front seatback minus 2.0 in. (51 mm).

L3 COMPARTMENT ROOM — SECOND. The dimension measured horizontally from the back of front seat to the front of the second seatback at a height tangent to the top of the second seat cushion.

W4 SHOULDER ROOM — SECOND. The minimum dimension measured laterally between trimmed surface on the "X" plane through the SgRP — second within 10.0-16.0 in. (254-406 mm) above the SgRP — second.

W6 HIP ROOM — SECOND. Measured in the same manner as W5.

H51 UPPER BODY OPENING TO GROUND — SECOND The dimension measured vertically from the trimmed body opening to the ground on the "X" plane 13.0 in (330 mm) forward of the SgRP — second.

Luggage Compartment Dimensions

V1 USABLE LUGGAGE CAPACITY — Total of volumes of individual pieces of standard luggage set plus H-boxes stowed in the luggage compartment in accordance with the procedure described in paragraph 8.2 of SAE-J1100a.

H195 LIFTOVER HEIGHT. The dimension measured vertically from the luggage compartment lower opening at the zero "Y" plane to ground.

Station Wagon — Third Seat Dimensions

PD3 PASSENGER DIRECTION — THIRD

W85 SHOULDER ROOM — THIRD. Measured in the same manner as W5.

W86 HIP ROOM — THIRD. Measured in the same manner as W5.

L86 EFFECTIVE LEG ROOM — THIRD. The dimension measured along a line from the ankle pivot center to the SgRP — third plus 10.0 in. (254 mm).

H86 EFFECTIVE HEAD ROOM — THIRD. The dimension measured along a line 8 deg. from the SgRP — third to the headlining rear of vertical plus a constant of 4.0 in. (102 mm).

H89 EFFECTIVE T-POINT HEAD ROOM — THIRD. Measured in the same manner as H75.

Station Wagon — Cargo Space Dimensions

L200 CARGO LENGTH — OPEN — FRONT. The minimum dimension measured logitudinally from the back of the front seatback at the height of the undepressed floor covering to the rearmost point on the undepressed floor covering on the open tailgate or cargo surface if the rear closure is a conventional door type tailgate, at the zero "Y" plane.

L201 CARGO LENGTH — OPEN — SECOND. The dimension measured logitudinally from the back of the second seatback at the height of the undepressed floor covering on the open tailgate or cargo floor surface if the rear closure is a conventional door type tailgate, at the zero "Y" plane.

L202 CARGO LENGTH — CLOSED — FRONT The minimum dimension measured horizontally from the back of the front seat at the height of the undepressed floor covering to the rearmost point on the undepressed floor covering on the closed tailgate or tail door for station wagons, trucks and mpv's at the zero "Y" plane.

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Interior Car And Body Dimensions — Key Sheet
Dimensions Definitions

L 203 CARGO LENGTH — CLOSED — SECOND The dimension measured horizontally from the back of the second seat at the height of the undepressed floor covering to the rearmost point on the undepressed floor covering on the closed tailgate or taildoor for station wagons, trucks and mpv's at the zero "Y" plane.

L 204 CARGO LENGTH AT BELT — FRONT. The minimum dimension measured horizontally from the back of the front seatback at the seatback top to the foremost normal surface of the closed tailgate or inside surface of the cab back panel at the height of the belt, on the zero "Y" plane.

L 205 CARGO LENGTH AT BELT — SECOND. The minimum dimension measured horizontally from the back of the second seatback at the seatback top to the foremost normal surface of the closed tailgate at the height of the belt, on the zero "Y" plane.

W 201 CARGO WIDTH — WHEELHOUSE. The minimum dimension measured laterally between the trimmed wheelhousings at floor level. For any vehicle not trimmed, measure the sheet metal.

W 203 REAR OPENING WIDTH AT FLOOR. The minimum dimension measured laterally between the limiting interferences of the rear opening at floor level.

W 204 REAR OPENING WIDTH AT BELT. The minimum dimension measured laterally between the limiting interferences of the rear opening at belt height or top of pick up box

W 205 REAR OPENING WIDTH ABOVE BELT. The minimum dimension measured laterally between the limiting interferences of the rear ooening above the belt height.

H 201 CARGO HEIGHT. The dimension measured vertically from the top of the undepressed floor covering to the headlining at the rear wheel "X" coordinated on the zero "Y" plane.

H 202 REAR OPENING HEIGHT. The dimension measured vertically from the top of the undepressed floor covering to the upper trimmed opening on the zero "Y" plane with rear door fully open.

H 250 TAILGATE TO GROUND (CURB WEIGHT). The dimension measured vertically from the top of the undepressed floor covering on the lowered tailgate to ground on the zero "Y" plane.

V 2 STATION WAGON

Measured in inches:

$$\frac{W4 \times H201 \times L204}{1728} = Ft.^3$$

Measured in mm:

$$\frac{W4 \times H201 \times L204}{10^9} = m^3 \text{ (cubic me}$$

V 4 HIDDEN CARGO VOLUME. As specified by the ma facturer.

Hatchback — Cargo Space Dimensions

All hatchback cargo dimensions are to be taken with the fr seat in full down and rear position, and the rear seat fo down. The hatchback door is in the closed position. (For e trically adjusted seats, see the manufacturer's specificat for Design "H" Point).

H197 FRONT SEATBACK TO LOAD HEIGHT. The di sion measured vertically from the horizontal tang to the top of the seatback to the undepressed flo covering.

L208 CARGO LENGTH AT FRONT SEATBACK HEIG The minimum horizontal dimension from the plane tangent to the rearmost surface of the driv seatback to the inside limiting interference of hatchback door on the vehicle zero "Y" plane.

L 209 CARGO LENGTH AT FLOOR — FRONT — HATC BACK. The minimum horizontal dimension measu at floor level from the rear of the front seatback to normal limiting interference of the hatchback do on the vehicle zero "Y" plane.

V3 HATCHBACK.

Measured in inches:

$$\frac{\frac{L208 + L209}{2} \times W4 \times H197}{1728} = Ft.^3$$

Measured in mm:

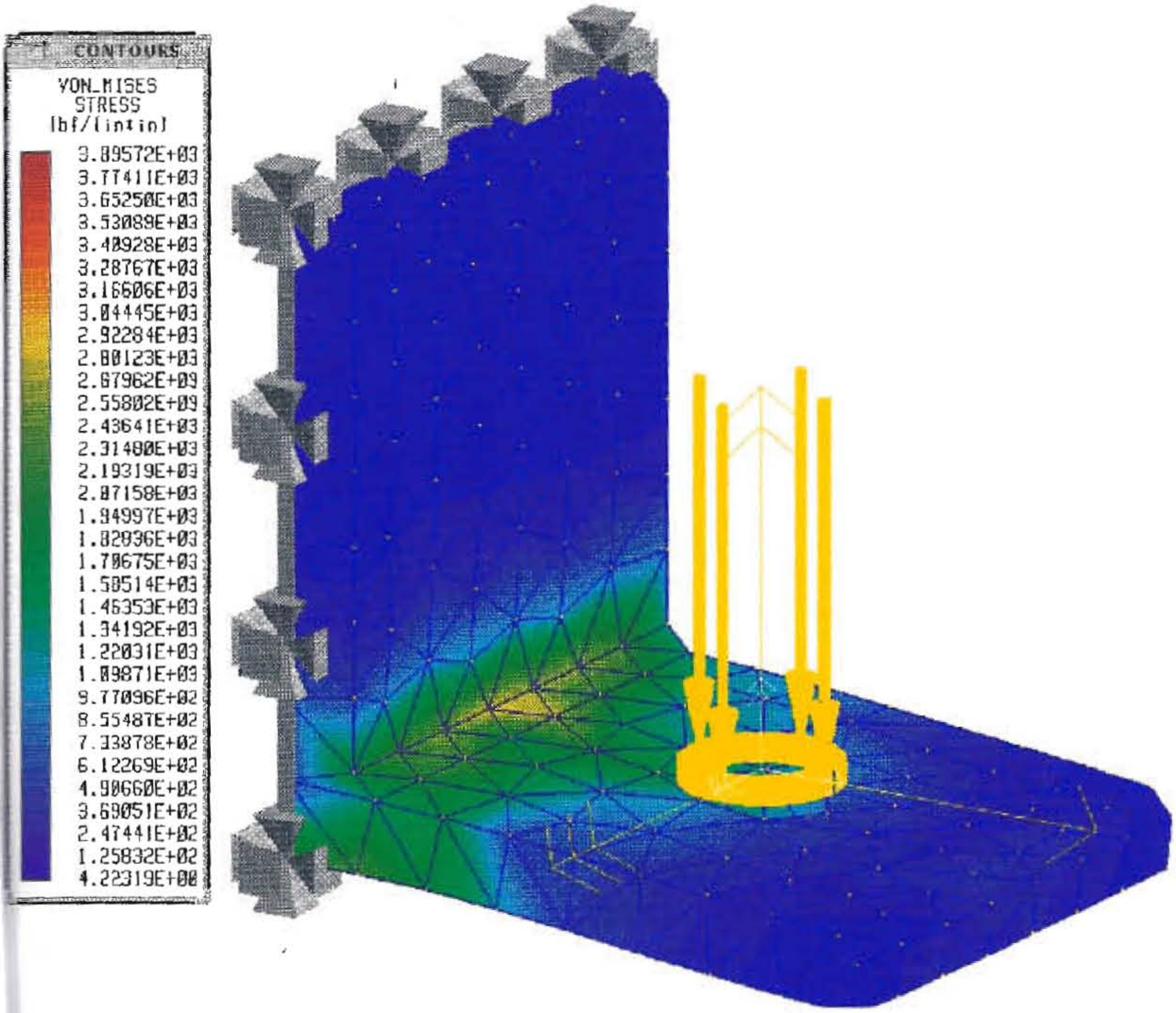
$$\frac{\frac{L208 + L209}{2} \times W4 \times H197}{10^9} = m^3 \text{ (cubic meter)}$$

MVMA Specifications Form
Passenger Car
METRIC (U.S. Customary)

Index

APPENDIX C

- Engine Stand calculations
- Finite Element Analysis of Engine Mount


CONTOURS
VON_MISES
STRESS
lbf/(in*in)
3.89572E+03
3.77411E+03
3.65250E+03
3.53089E+03
3.40928E+03
3.28767E+03
3.16606E+03
3.04445E+03
2.92284E+03
2.80123E+03
2.67962E+09
2.55802E+09
2.43641E+03
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1.70675E+03
1.58514E+03
1.46353E+03
1.34192E+03
1.22031E+03
1.09871E+03
9.77096E+02
8.55487E+02
7.33878E+02
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4.90660E+02
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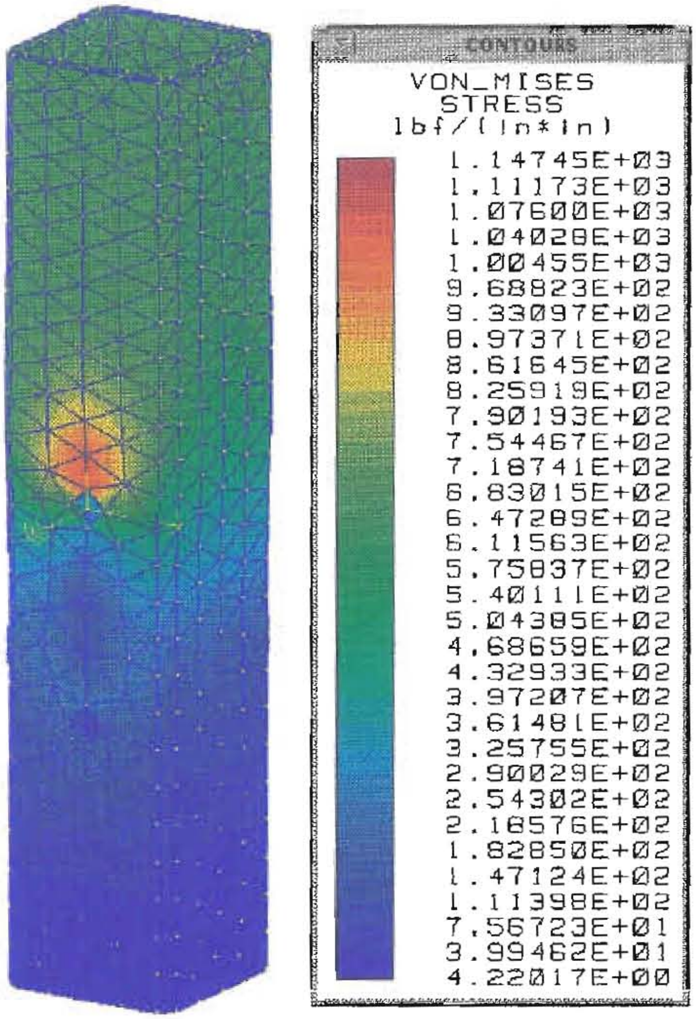
4.22319E+00


CONTOURS
VON_MISES
STRESS
lbf/(in*in)
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1.11173E+03
1.07600E+03
1.04028E+03
1.00455E+03
9.68823E+02
9.33097E+02
8.97371E+02
8.61645E+02
8.25919E+02
7.90193E+02
7.54467E+02
7.18741E+02
6.83015E+02
6.47289E+02
6.11563E+02
5.75837E+02
5.40111E+02
5.04385E+02
4.68659E+02
4.32933E+02
3.97207E+02
3.61481E+02
3.25755E+02
2.90029E+02
2.54302E+02
2.18576E+02
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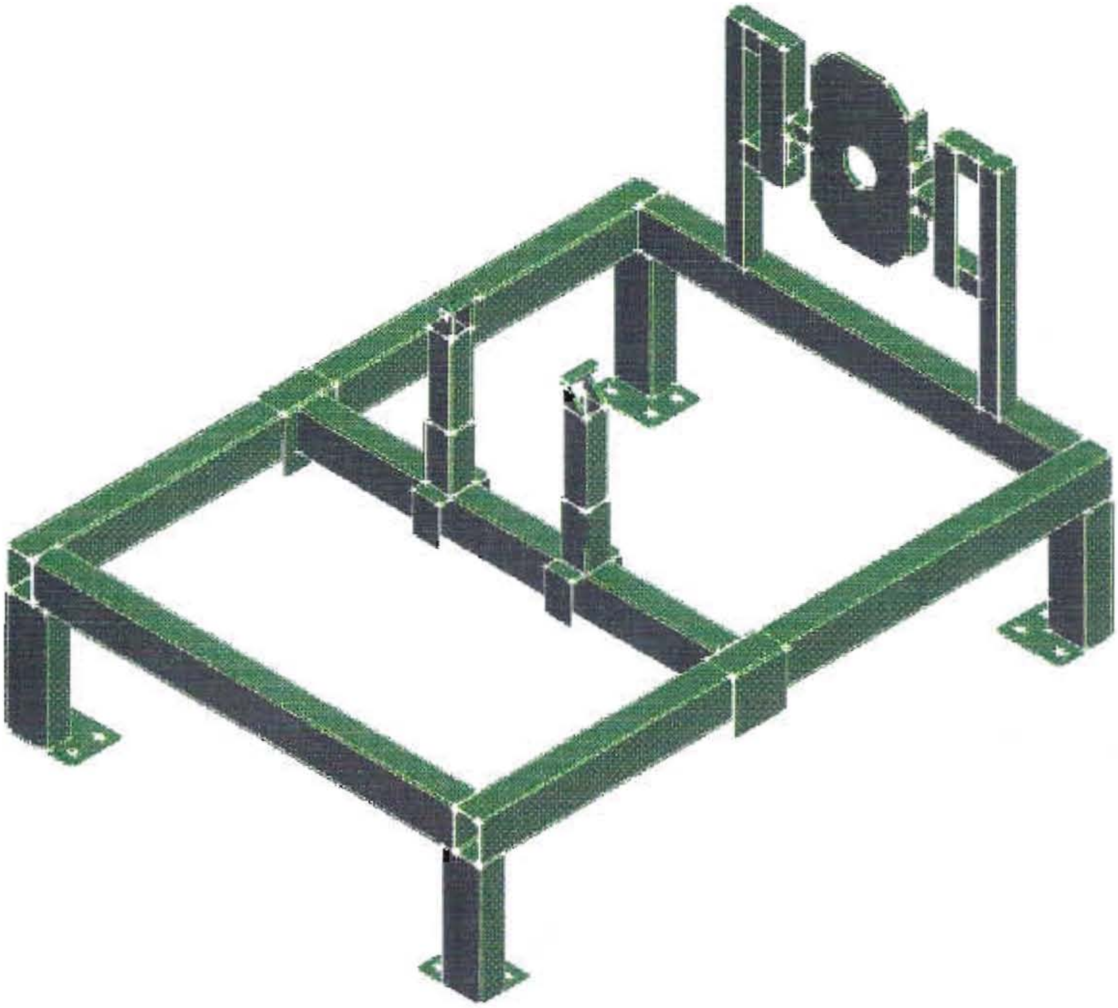
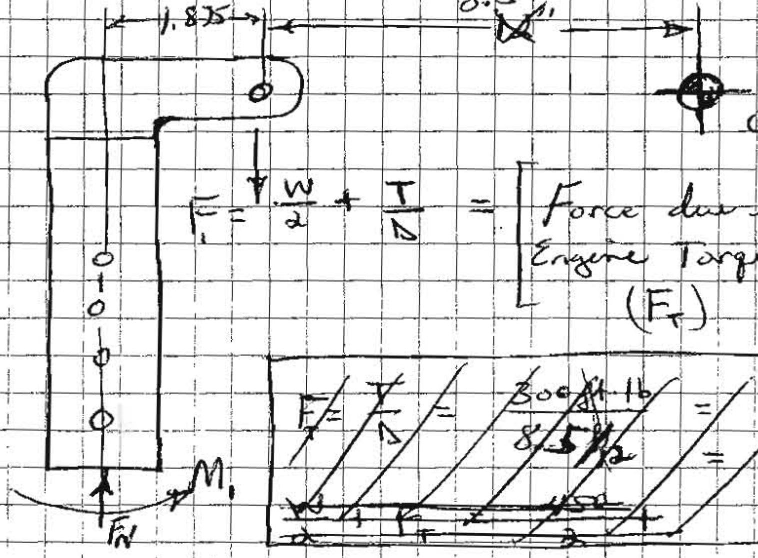
1.47124E+02
1.11398E+02
7.56723E+01
3.99462E+01
4.22017E+00



Calculations based on using V-8 Engine with GW of 450 lbs
Peak 300 ft-lb of torque

Left Front Engine Support:



$F_1 = \frac{W}{2} + \frac{T}{D}$ = [Force due to Engine Torque (F_T) + ½ Weight of Engine]

~~$F_T = \frac{T}{D} = \frac{300 \text{ ft-lb}}{8.5/12} = \frac{300 \text{ lb}}{} = 35.29 \text{ lbs} = 423.5 \text{ lbs}$~~

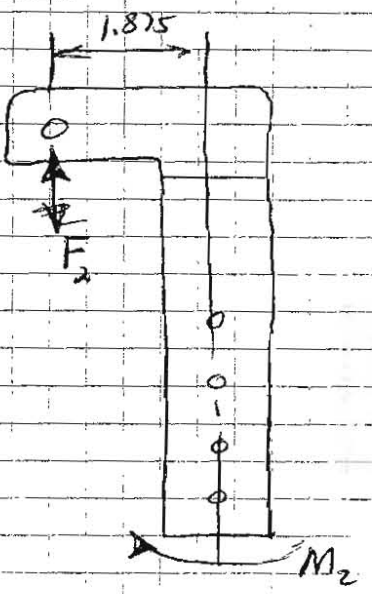
~~$\frac{W}{2} + F_T = \frac{450}{2} +$~~

- $F_T = \frac{T}{D} = \frac{300 \text{ ft-lb}}{(8.5/12)} = \boxed{423.5 \text{ lbs.}}$

- (+↓) $F_1 = \frac{W}{2} + \frac{T}{D} = \frac{450 \text{ lbs}}{2} + 423.5 \text{ lbs} = \boxed{648.5 \text{ lbs}}$

$M_1 = F \times D = 648.5 \text{ lb} * \frac{1.875 \text{ in}}{12} = \underline{101.3 \text{ ft-lbs}}$

Right Front Engine Support:
(Same bracket)

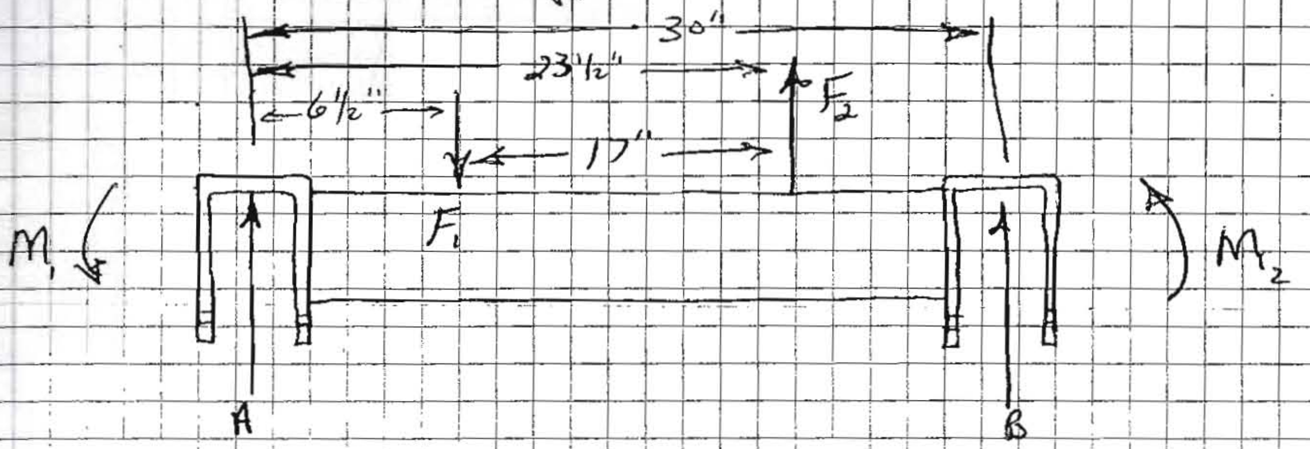


(+↑) $F_2 = -\frac{W}{2} + 423.5 = \boxed{198.5 \text{ upward.}}$

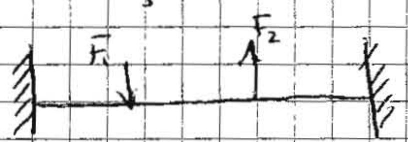
$M_2 = 198.5 * \frac{1.875}{2} = \underline{31 \text{ ft-lbs}}$

& 300 ft lbs torque

Cross Support:



Statically Indeterminent Case:



Calculations for when Engine RPM is increased to max. output. [300 ft lbs torque]

$\overset{+}{\rightarrow} \sum F_x = 0$

$+\downarrow \sum F_y = 0 = 648.5 - A - B - 198.5$

$+\circlearrowleft \sum M_A = 0 = -648.5(6.5/12) + 198.5(23½/12) + B(30/12)$

$\boxed{F_B = 14.98 \text{ lbs}}$

$F_A = -648.5 + 14.98 + 198.5$

$\boxed{F_A = 435.02 \text{ lbs}}$

$I = \left[\frac{1}{12} b h^3\right]_{OD} - \left[\frac{1}{12} b h^3\right]_{ID} = \frac{1}{12}(2")(3")^3 - \frac{1}{12}(1.75)(2.75")^3$

$\boxed{I = 1.42 in^4}$ for 2" x 3" Rectangular Tubing ⅛" wall

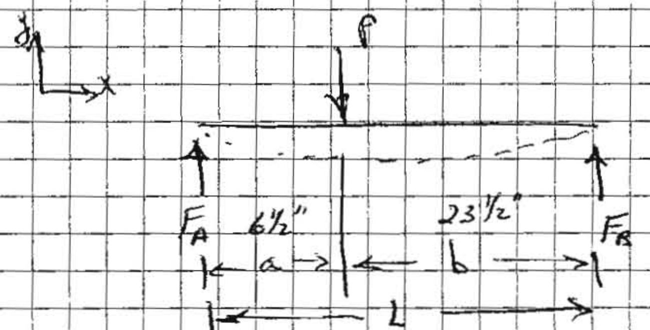
$\boxed{E \text{ of CRS} = 29 \times 10^6 \text{ psi}}$

Cross Support: (continued)

Deflection $Y_{max} = \frac{-PL^4}{384\,EI}$ for Statically Indet. Case

$$Y_{max} = \frac{-(648 - 14.98)(15\,in)^4}{384\,(29\times10^6)(1.47)} = .002\,in$$

or using case for concentrated Force at any pt.
Neglecting the 14.98 lbs (Assuming this is negligable)



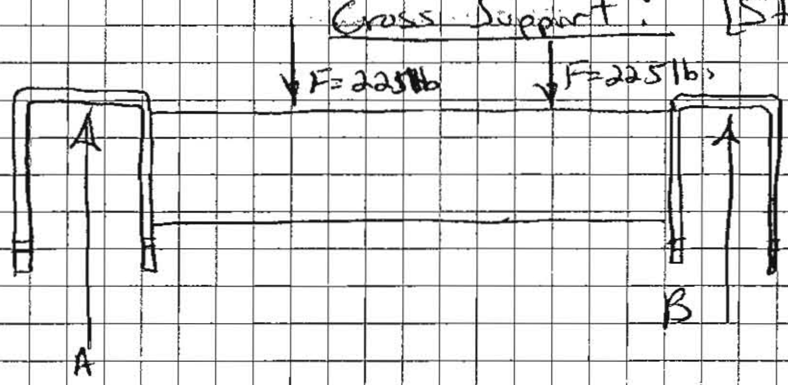
~~$Y_{max} = \frac{-Pa}{24\,EI}(3L^2 - 4a^2)$ at center of Beam~~

★ $$Y_{max} = \frac{-Pab\,(a+2b)\sqrt{3a(a+2b)}}{27\,L\,EI}$$

$$Y_{max} = \frac{(648-14.98)(6.5'')(23.5'')\left[6.5'' + 2(23\tfrac{1}{2})\right]\sqrt{3(6.5)[6.5+2(23.5)]}}{27\,(30)(29\times10^6)(1.47)}$$

$$Y_{max} = .005\,in$$

Cross Support: [Static Loading]

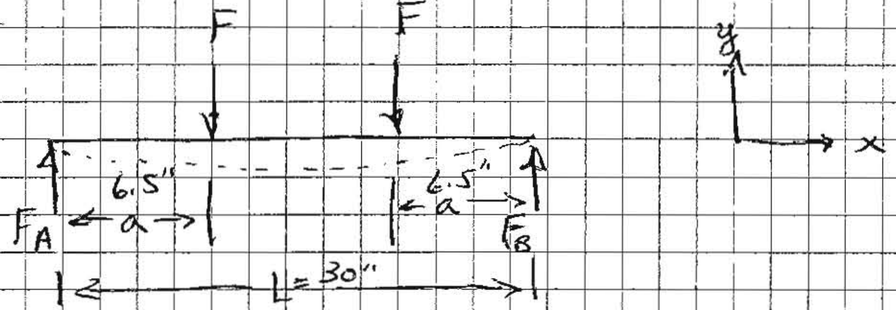


$$\Sigma M_A = 0 = (225)\left(\frac{6.5}{12}\right) + 225\left(\frac{23\frac{1}{2}}{12}\right) + B\left(\frac{30}{12}\right)$$

$$\boxed{F_B = 225 \text{ lbs} \qquad F_A = 225 \text{ lbs}}$$

Static Loading

~~Ymax F~~



Two equal concentrated Forces symmetrically placed

$$Y_{max} = \frac{-Pa}{24EI}\left(3L^2 - 4a^2\right)$$

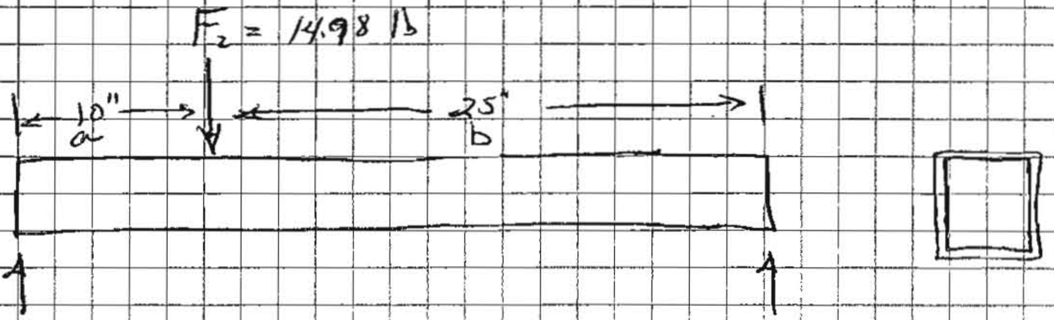
$$= -\frac{(225)(6.5)}{24(29\times10^6)(1.47)}\left(3(30)^2 - 4(6.5)^2\right)$$

$$\boxed{Y_{max} = .004 \text{ in}}$$

Static Loading

Main Frame member (side) Right

at max Engine RPM & (torque = 300 ft lbs)



$$Y_{max} = \frac{-Pab(a+2b)\sqrt{3a(a+2b)}}{27 L EI} =$$

$$= \frac{-14.98(10")(25)(10+2(25))\sqrt{3(10)(10+2(25))}}{27(35)(29\times10^6)(1.47)}$$

$Y_{max} = .0002$ in dynamic loading

$Y_{max} = .003$ in static loading $P = 225$

Main Frame (side left)

same positioning as above:

$P = 648$ lb

$$Y_{max} = \frac{648(10)(25)(10+2(25))\sqrt{3(10)(10+2(25))}}{27(35)(29\times10^6)(1.47)}$$

$Y_{max} = .01$ in dynamic loading

Static loading is same as above

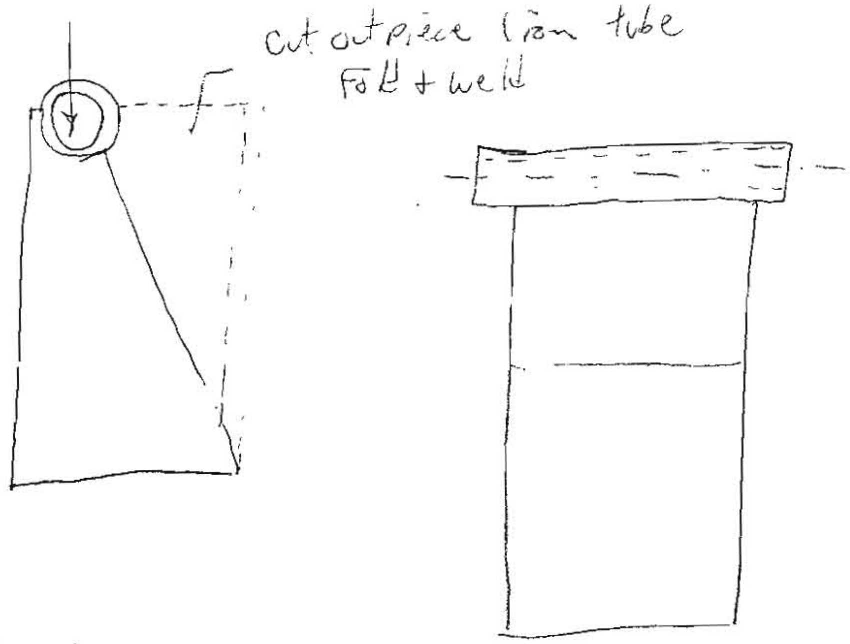
3-6-96

head piece Aries / Ansys data done.

3-8-96 head piece manufacture is causing problems
-correct cutting tools not working.

New design of support:

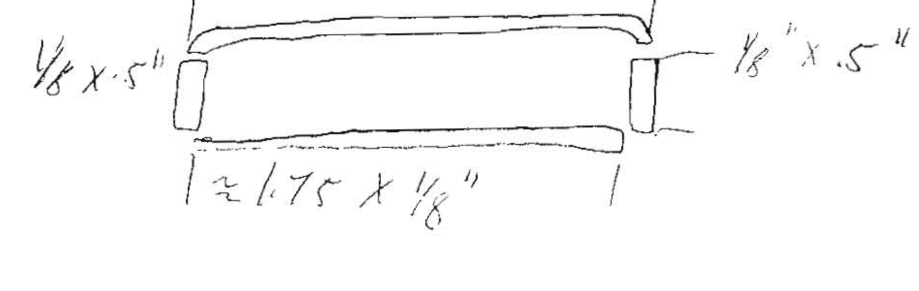
Sketches



new stress calculations

625 lbs ↓

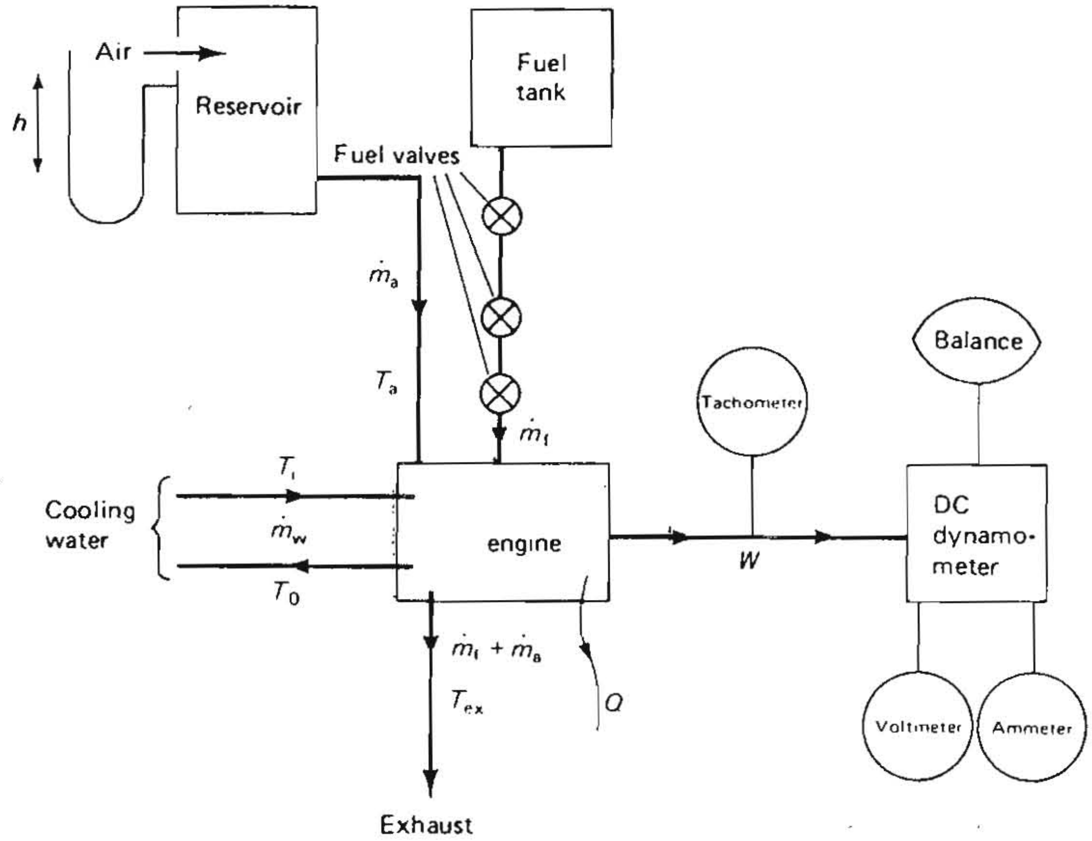
$\sigma = \frac{F}{A}$ A = cross sectional Area of [illegible] part of support.



APPENDIX D

- Placement of measurement Devices
- Air Chamber and Flow Nozzle Design

Measurement Devices



Air Chamber Design

Calc based on max flow rate into carburator.

① Volumetric flow rate:

$$Q = \frac{\text{rpm} \times \text{displacement of cyl.}}{3456} = \text{CFM}$$

based on 98 in³ displacement

- Volume displaced on intake strokes during each revolution is ½ of the overall capacity

$$\text{so} \quad \text{Air capacity} = \frac{\text{rpm} \times \text{displ.}}{2} \quad in^3/min$$

$$\text{\& to get CFM} = \frac{\text{rpm} \times \text{displ}}{2(1728)} = ft^3/min$$

$$V.E. = \frac{\text{Actual CFM}}{\text{Theoretical CFM}} \times 100$$

Changed to metric for ease of calculations.

$Q = VA$

$\dot{m} = \rho_A VA$

$A = .0014\ m^2$

ρ_A at $65° = 1.21\ kg/m^3$

$Q_{max} = .069\ m^3/s$

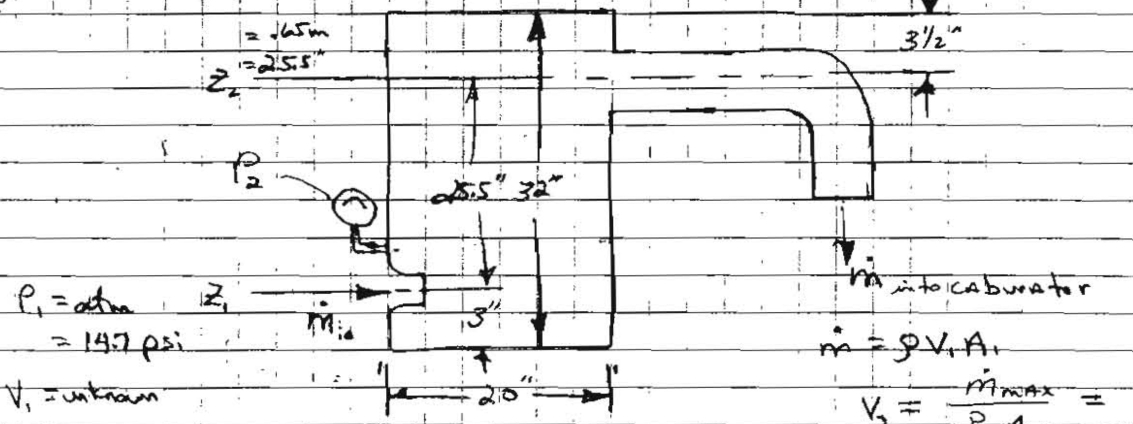
② Velocity of Air into carburator

$$V = \frac{\dot{m}}{\rho A} = 60.2\ m/s \quad \text{at } 5200 \text{ rpm}$$

Bernoulli's Equation

$$\frac{P_1}{\rho_a} + \frac{V_1^2}{2} + g\cancel{Z_1}^{\,0} = \frac{P_2}{\rho_a} + \frac{V_2^2}{2} + gZ_2 + \cancel{h_L} \quad \text{(Neglect)}$$

$$\frac{N/m^2}{kg/m^3}$$



$\dot{m} = \rho V_1 A_1$

$V_2 = \frac{\dot{m}_{MAX}}{\rho A_1} =$

Guide lines for Design from SAE Standards (SAE J1088 Feb 93)

- Damping Chamber internal Volume:

★ Not less than 100 times displacement per cylinder under test

★ - Pressure drop not to exceed 100 Pa = .015 psi

Assumptions made:

- incompressible flow:
- Steady Flow:
- Flow through a Fixed Volume:
- Constant Pressure & Temperature

then MAX

$$V_{2_{MAX}} = \frac{\dot{m}_{MAX}}{\rho_a A_1} = \frac{.083\ kg/s}{(1.21\ kg/m^3)(.00114\ m^2)} = 60.2\ m/s = 197.4\ ft/s$$

from Bernoulli's & (Assume ΔP at its MAX 100 Pa)

$$\frac{kg\,m/s^2}{m^2} = kg/m\,s^2 \quad m^3/kg \quad m^2/s^2$$

$$P_1 - P_2 = V_2^2 - V_1^2 + gZ_2$$

$$V_1 = \sqrt{V_2^2 - \Delta P - gZ_2} = \sqrt{(60.2\ m/s)^2 - \left[\frac{100\ N/m^2}{1.21\ kg/m^3}\right] - \left[(9.81\ m/s^2)(.65m)\right]}$$

$\boxed{V_1 = 59.3\ m/s}$

4-30-96

Carburator air intake flow rate

$$Q = CFm = \frac{rpm \times displacement}{3456}$$

MAX 5200 rpm

$$CFm = \frac{5200\ rpm \times 98\ in^3}{3456\ in^3/ft^3} = \boxed{147.5\ ft^3/min}\ \text{MAX}$$

$$CFm = \frac{1000\ rpm \times 98\ in^3}{3456\ in^3/ft^3} = \boxed{28.4\ ft^3/min}\ \text{min.}$$

$$\dot{m} = \rho Q \qquad \frac{slug}{ft^3} \cdot ft^3/min = slug/min$$

Where ρ = Density of Air in Room $\approx 1.21\ kg/m^3$ at 6
V = Velocity of Air (unknown)
A = Cross sectional Area of Carburator inlet.

Metric | U.S

Density of air at 63°F: $1.21\ kg/m^3 \cdot \frac{1m^3}{35.31 ft^3} \cdot \frac{.0685\ slugs}{1 kg} = .00235\ slugs/ft^3$

$$Q_{MAX} = 147.5\ ft^3/min \cdot \frac{.028\ m^3}{1\ ft^3} \cdot \frac{1 min}{60 s} = .069\ m^3/s$$

$$Q_{min} = 28.4\ ft^3/min = .013\ m^3/s$$

$$\dot{m}_{max} = \rho_a Q_{max} = (1.21\ kg/m^3)(.069\ m^3/s) = .083\ kg/s$$

$$\dot{m}_{min} = (1.21\ kg/m^3)(.013) = .0157\ kg/s$$

$Q = VA$

$\dot{m} = \rho VA$

Conservation of mass

$$\dot{m}_1 = \dot{m}_2$$

$$\therefore A_1 V_1 = A_2 V_2$$

Into Carburator

$$\dot{m}_{max} = \rho VA$$

Velocity of Air $V = \frac{\dot{m}}{\rho A}$

4-12-96

Air Flow Rate Measurement

Piston Displacement:

1605 cm^3 (98 in^3)

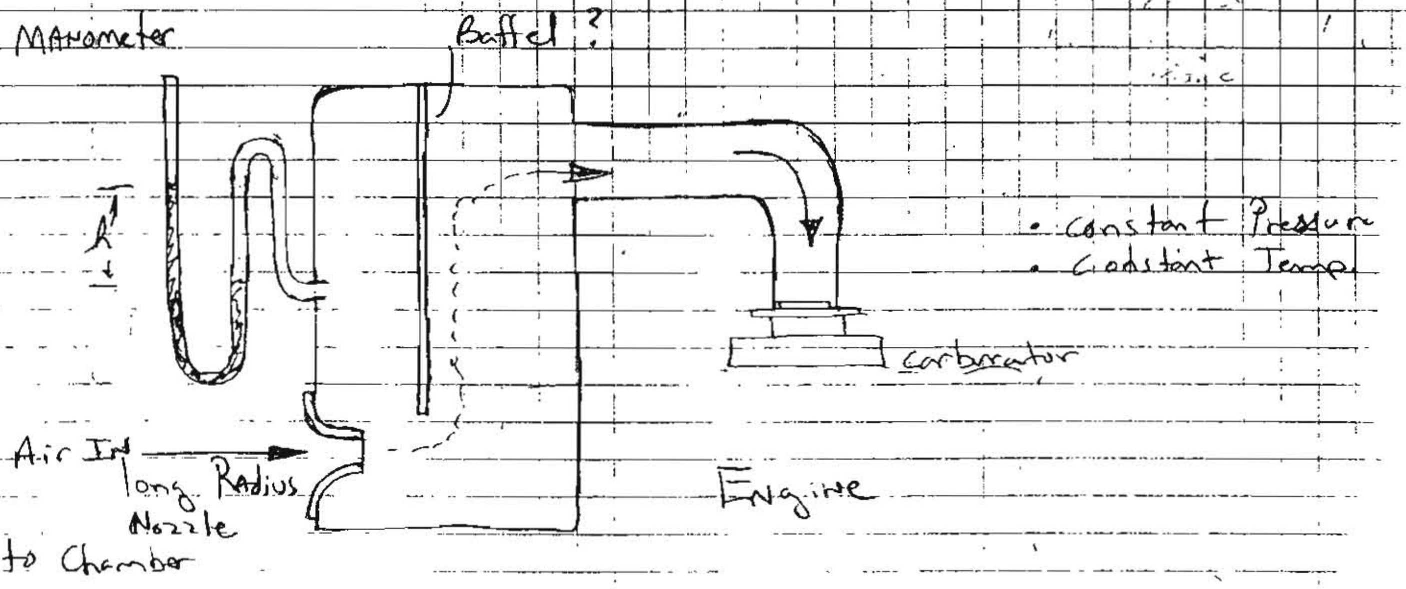
Test Procedure for measurement of Gaseous Exhaust emissions:

SAE J1088 Feb 93

The measurement system should consist of a laminar flow meter used in conjunction with a pressure wave damping chamber in order to damp out pulsations in air flow.

Design Parameters:

- internal volume of pressure vessel: not less 100 times the displacement per cylinder
- Pressure drop not to exceed 100 Pa



Manometer used to measure ΔP.

③ Velocity of air through nozzle:

from Bernoulli's:

Assume ΔP at its max

$$\Delta P = V_2^2 - V_1^2 + g z_2$$

→ $V_2 = \sqrt{V_2^2 - \Delta P - g z_2} = 59.3 \text{ m/s}$

④ To find Area of nozzle inlet:

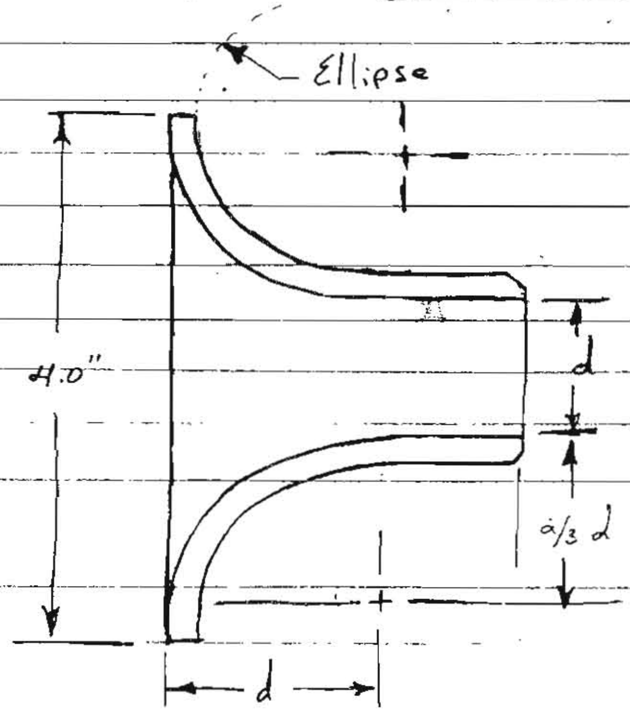
Assume density of air is same at inlet of carb. & nozzle

$$V_1 A_1 = V_2 A_2$$

→ $A_1 = \dfrac{V_2 A_2}{V_1} = .0012 \text{ m}^2$

$$A = \frac{\pi d^2}{4}$$

→ $d = \sqrt{\dfrac{4A}{\pi}} =$ 1.51" dia



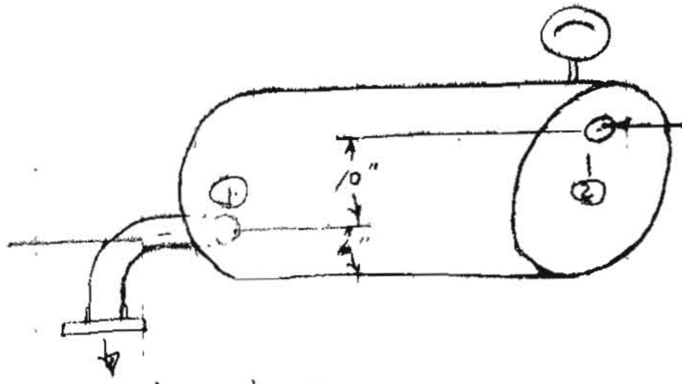
Vol. Efficiency:

$$V.E. = \frac{Q_{actual}}{Q_{Theor}} \times 100$$

From Bernoulli's

determine Velocity of air through Nozzle & Find Q_{Actual}

Air Chamber 22" Dia × 34"



$\dot{m}_{\text{into chamber}} = \rho_{air} V_2 A_2$

V_2 = unknown

$\dot{m}_{\text{into carb}} = \rho_{air} V_1 A_1$

$$Q_{max} = \frac{rpm \times Displ.}{2(1728)} = 148\ CFM = .069\ m^3/s$$

$$V_1 = \frac{\dot{m}}{\rho A} = 60.2\ m/s \text{ at } 5200\ rpm$$

$$V_2 = \sqrt{V_1^2 - \Delta P - g z_2} = 59.3\ m/s$$

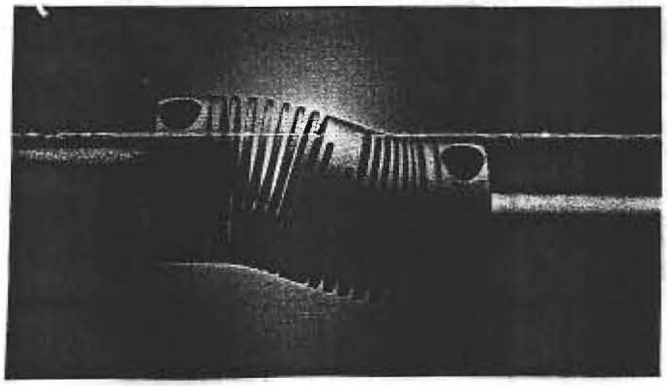
$$V_1 A_1 = V_2 A_2$$

$A_2 = .0012\ m^2$ ∴ Dia of nozzle inlet = **1.51"**

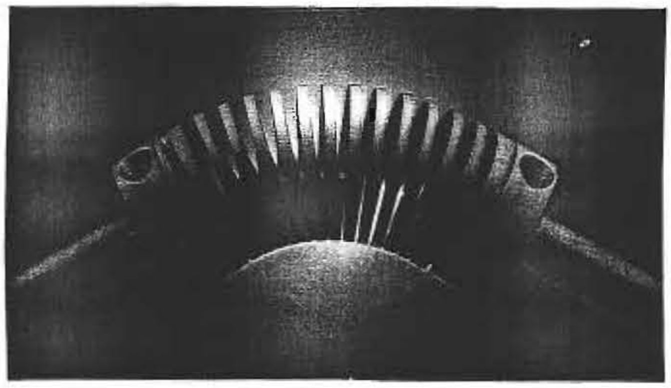
APPENDIX E

- **Drive Shaft Design**

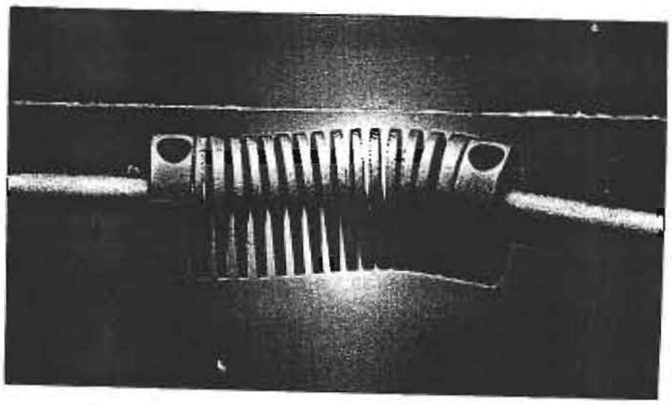
PARALLEL



ANGULAR



SKEWED



APPENDIX F

- **Heat Exchanger Design**

Temps:

$T_{h\,in} = 235\,°F = 112.7\,°C$ } Ethylene glycol

$T_{h\,out} = 220\,°F = 104.4\,°C$ }

C_p ethylene Glycol $= 2742 \frac{J}{kg\,°C}$ at 100 °C

C_p water $= 4.1818 \frac{J}{kg\,°C}$ at 15.5 °C

$$\dot{m}\ \text{Glycol} = \frac{14\ gal}{min} \times .003.78 \frac{m^3}{gal} \times \frac{1\ min}{60\ s} = 8.768E{-4}\ m^3/s$$

$$8.768E{-4} \frac{m^3}{s} \times 1058.5 \frac{kg}{m^3} = \boxed{.928 \frac{kg}{s}}$$

Effectiveness $\varepsilon = \dfrac{C_h\,(T_{h,in} - T_{h\,out})}{C_{min}\,(T_{h,in} - T_{c,in})}$

$$C_h = m_h C_{ph} = .928 \frac{kg}{s} \times 2742 \frac{J}{kg\,°C} = 2544\ W/°K$$

$$C_c = .5 \frac{kg}{s} \left(4.1818 \frac{kJ}{kg\,°C}\right) = 2090.9\ W/°K$$

$$C_{min} = C_c < C_h \Rightarrow 2090.9\ W/°C$$

$$\varepsilon = \frac{2544 \frac{W}{°C}\,(112.7 - 104.4)\,°C}{2090.9 \frac{W}{°C}\,(112.7 - 15.5)\,°C} = .1038\ \%$$

$$C = \frac{C_{min}}{C_{max}} = \frac{2090.9}{2544} = .82$$

By Fig. 12.10 in Heat Transfer Book

NTU = ~~.2~~ by calc = .115

$$NTU = \frac{A\ U_m}{C_{min}}$$

Now calculate U_m — Assume thin walled tubing so Neglect wall resistance:

$$U = \frac{1}{\frac{1}{h_i} + \frac{1}{h_o}}$$

h_i: Properties of Ethylene Glycol at 112.7 °C

$V = 2.0\ m^2/s \times 10^{-6}$

$K = .263\ W/m\cdot K$

$Pr = 22.4$

h_i: $Re = \frac{12.83 \frac{m}{s} (.00935\ m)}{2.0 \times 10^{-6} \frac{m^2}{s}} = 59980.25$ ∴ Turbulent

$Nu = .023\ Re^{0.8}\ Pr^{0.3} = 388.3$

$h_i = Nu \frac{K}{D_i} = \frac{(388.3)(.263)}{.00935} = 10923.2 \frac{W}{m^2\ °C}$

$\frac{14 \text{ gal}}{\text{min}} \times \frac{.003785 \text{ m}^3}{\text{gal}} = \frac{.05299 \text{ m}^3}{\text{m}} = 8.831 E\text{-}4 \frac{\text{m}^3}{\text{s}}$

$\dot{m} = \rho . \dot{V} = 1058.5 \frac{\text{kg}}{\text{m}^3} \times 8.831 E\text{-}4 \frac{\text{m}^3}{\text{s}} = .934 \frac{\text{kg}}{\text{s}}$

U 8g 3/8" = .935 cm = .00935 m

$\frac{8.81 E-4 \frac{m^3}{s}}{\frac{\pi (.00953)^2}{4}} = 12.35 \, m/s$ ⟸ 1 tube

Two tubes = 6.17 m/s

3 Tubes = 4.16 m/s

Two tubes:

$Re = \frac{(6.4)(.00953)}{2.0 E-6} = 29920$

$Nu = .023 (29920)^{.8} (22.4)^{.3} = 222.6$

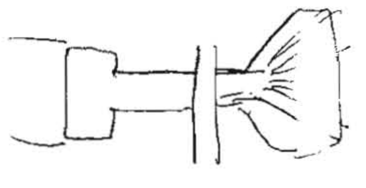
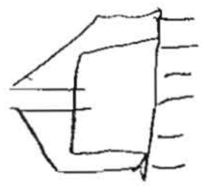
$h_i = \frac{(222.6)(.263)}{.00953} = 6262 \; W/m^2 \, ^\circ C$

---

3 Tubes: $Re = \frac{(4.16)(.00953)}{2.0 E^{-6}} = 19615.9$

$Nu = .023 (19615.9)^{.8} (22.4)^{.3} = 158.8$

$h_i = \frac{(158.8)(.263)}{.00953} = 4382.8 \frac{W}{m^2 \, ^\circ C}$

check with 1/2" ID Pipe: 3 pipes 1.27 cm D

$\dot{m} = 8.81 \epsilon{-4}\ \frac{m^3}{s}$

$V = \frac{8.81\epsilon{-4}}{\frac{\pi(.0127)^2}{4}} = 6.95\ m/s$ One Pipe

Two Pipes = 3.47 m/s

3 Pipes = 2.316 m/s

4 Pipes = 1.73 m/s Two coil configuration

$Re = \frac{U_m D}{\nu} = \frac{(1.73)(.0127)}{2.0\epsilon{-6}} = 10985.5$

$Nu = .023\,(10985.5)^{.8}(22.4)^{.3} = 99.87$

$h_i = Nu \frac{K}{D_i} = 20.68 \cdot 2\ W/m^2 K$

h_o: $D_o = D_i + 2/8" = .5 + 1/4 = .75" \Rightarrow 1.905$ cm

$Gr_D = \frac{g\beta(\Delta T)D^3}{\nu^2}$

$g = 9.81\ m/s^2$

$\beta = 2.1\epsilon{-4}\ 1/K$

Avg of T_{hi} & T_{ho}

$\Delta T = (108.55 - 15.5) = 93.05\ C$

$Gr = \frac{9.81(2.1\epsilon{-4})(93.05)(.01905)^3}{(1.006\epsilon{-6})^2}$

$= 1,309,464.286$

$< 10^6$

$Pr = 700$

$Re = Gr\ Pr = 916625\ 0.002$

$Nu_D = 0.53\,(Gr_D\,Pr)^{1/4}$ P. 333 Principles of Heat Trans.

$Nu_D = 27.5$

$h = \frac{Nu\,k}{D} = \frac{27.5(.597)}{.01905}$ 861.81 $\frac{W}{m^{2}\,{}^{\circ}K}$

$$U = \frac{1}{\frac{1}{h_i} + \frac{1}{h_o}} = 608.3\ \frac{W}{m^{2}\,{}^{\circ}K}$$

Now calculate Area of Pipe using $NTU = \frac{U_m A}{C_{min}}$

$$A = \frac{NTU\ C_{min}}{U_m} = \frac{(.2)(2090.9)\ \frac{W}{{}^{\circ}K}}{608.3\ \frac{W}{m^{2}\,{}^{\circ}K}}$$

$A = .687\ m^2$

$\frac{A}{A_c}$ $L = \frac{.687\ m^2}{\pi(.01905)m}$ = 11.48 m of Pipe cut into 4 sections = each pipe is 2.8 m per section

2.8 m per pipe section
of 1/2" dia copper pipe

New length

$\frac{.187\ m^2}{\pi(.01905\ m)}$ = 3.12 m of 1/2" pipe

$\nu = \mu / \rho$ $\dot{m} = \rho \dot{V} = \rho V A = \frac{\pi D^2 \rho V}{4}$

$$Re = \frac{V D \rho}{\mu} = \frac{4 \dot{m} \rho}{\pi D \nu \rho} = \frac{4 \dot{m}}{\pi D \cdot 10^{-6} \cdot 1059}$$

$D = 0.0127 m$ $\dot{m}_c = 0.928 kg/s$

1 pass ~~$Re_1 = 43900$~~ ~~$Re_2 = 22000$~~ $Re_4 = 11000$

$Nu = 100$ $h_i = 2070 \; W/m K$

8.25" $Re = \frac{4 \dot{m}}{\pi D \nu \rho} = \frac{4 \cdot 0.5}{\pi \cdot 0.21 \cdot 0.8 \cdot 10^{-3} \cdot 0.79 \cdot 10^{-3}} = 4800$

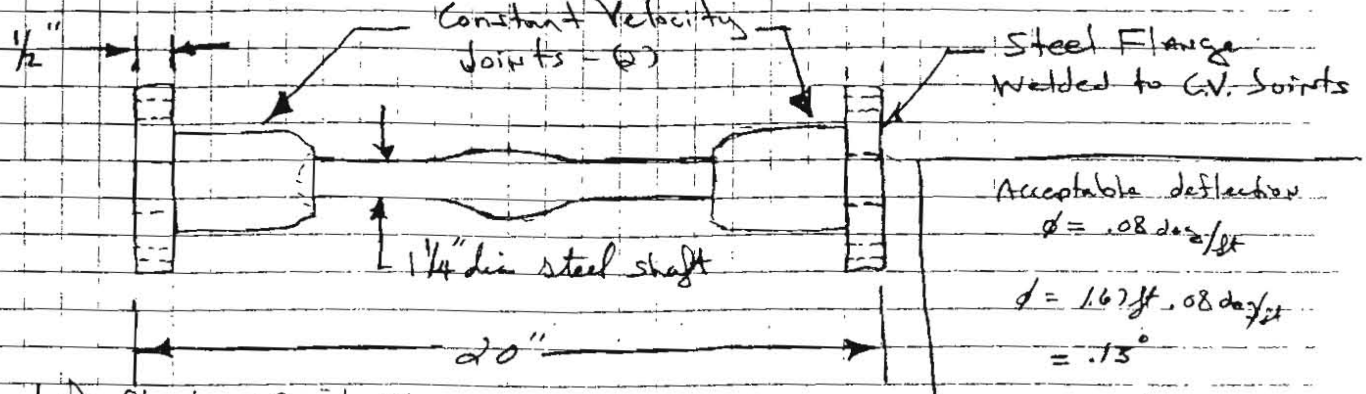
$Nu \approx 10.5$ $Nu = \sqrt{105^2 + 27.5^2} = 108$

$h = 3400$ $U = 1280$

$$A = \frac{NTU \; C_{min}}{U_m} = 0.187 m^2$$

4-23-96

Drive Shaft



Acceptable deflection

$\phi = .08$ deg/ft

$\phi = 1.67$ ft $\cdot .08$ deg/ft

$= .13°$

Torsional Deflection for shafts:

$$\phi = \frac{584\, T L}{G d^4}$$

$$= \frac{584\,(300 \text{ ft lb})(1.67 \text{ ft})}{(12\times10^6 \text{ lb/ft}^3)\,(.104 \text{ ft})^4}$$

$= 1.67 \times 10^{-4}$ ft $=$ **.002 in** max deflection

where ϕ = Angle of twist

G = for Steel (Modulus of Shear) $= 12\times10^6$ lb/ft^3

T = Torque applied ft lbs.

L = length of Shaft

d = dia. of shaft

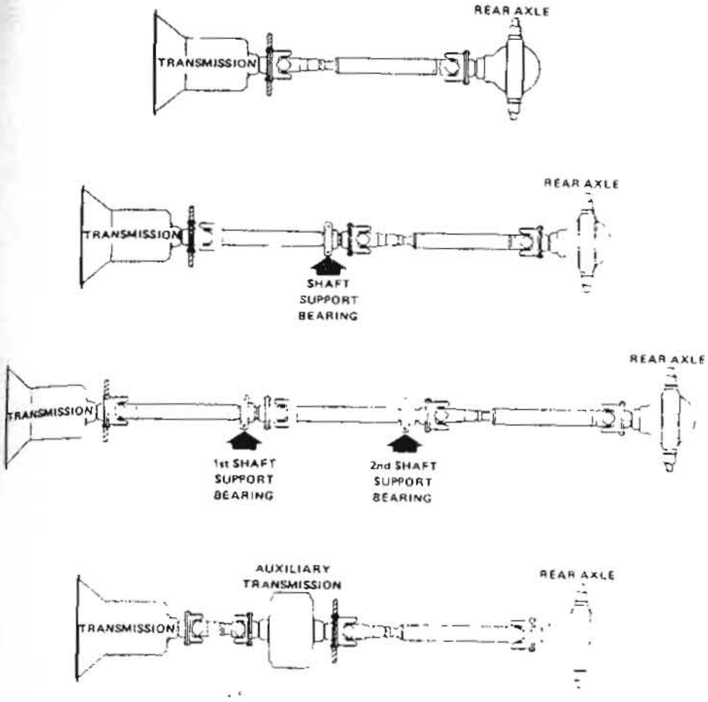


FIGURE 37—TYPICAL 4 X 2 AND 6 X 2 TRUCK DRIVELINE ARRANGEMENTS

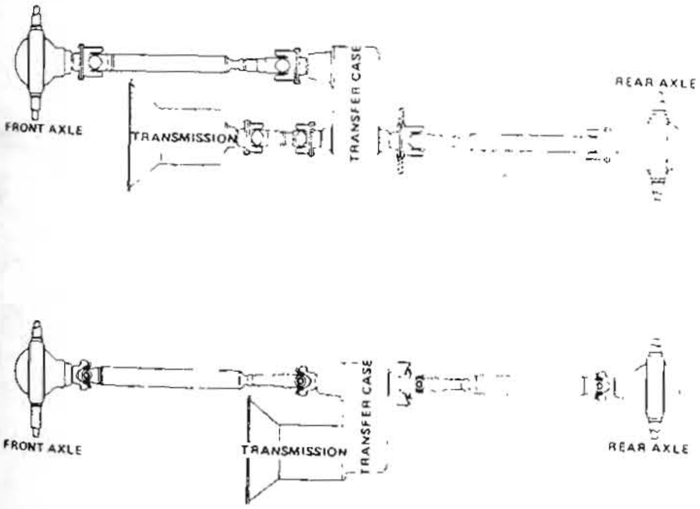


FIGURE 38—TYPICAL 4 X 4 TRUCK DRIVELINE ARRANGEMENTS

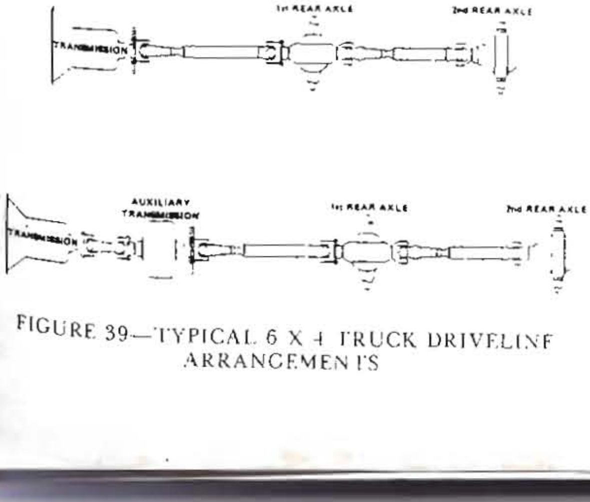


FIGURE 39—TYPICAL 6 X 4 TRUCK DRIVELINE ARRANGEMENTS

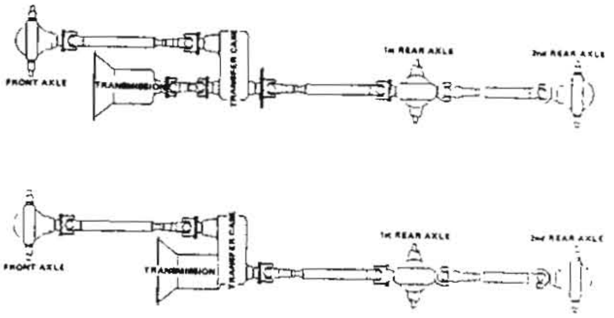


FIGURE 40—TYPICAL 6 X 6 TRUCK DRIVELINE ARRANGEMENTS

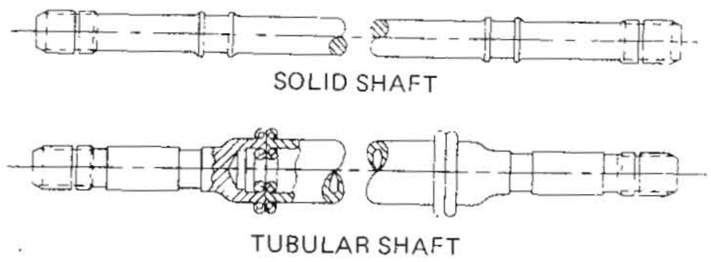


FIGURE 41—SOLID AND TUBULAR AXLE SHAFTS

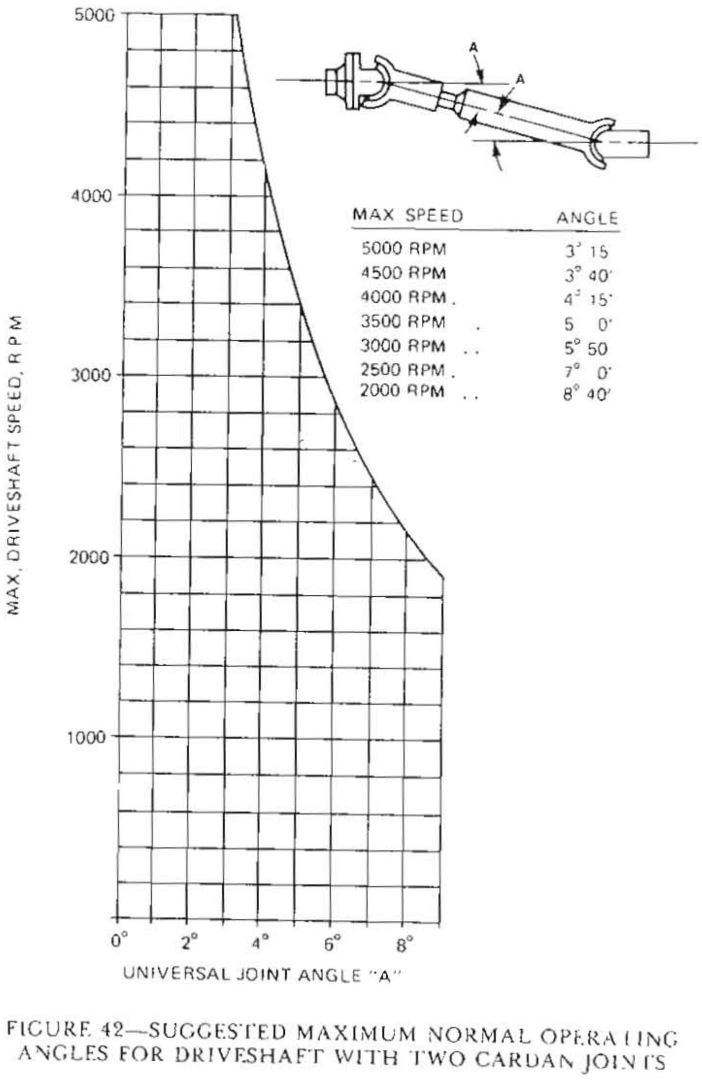


FIGURE 42—SUGGESTED MAXIMUM NORMAL OPERATING ANGLES FOR DRIVESHAFT WITH TWO CARDAN JOINTS

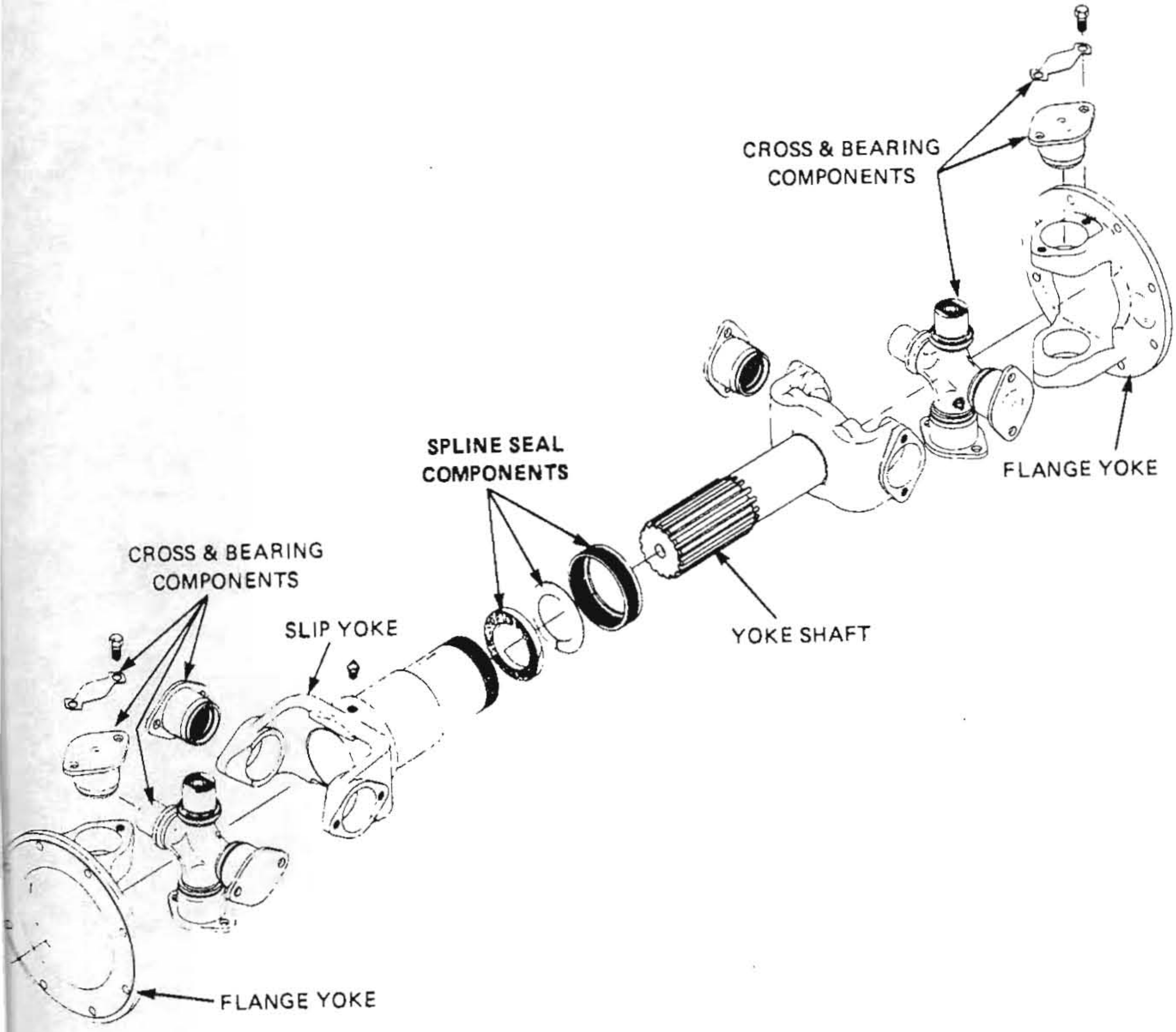


FIGURE 36—TYPICAL SHORT COUPLED DRIVESHAFT