Chapter 8. **Building a good breathing cylinder head**

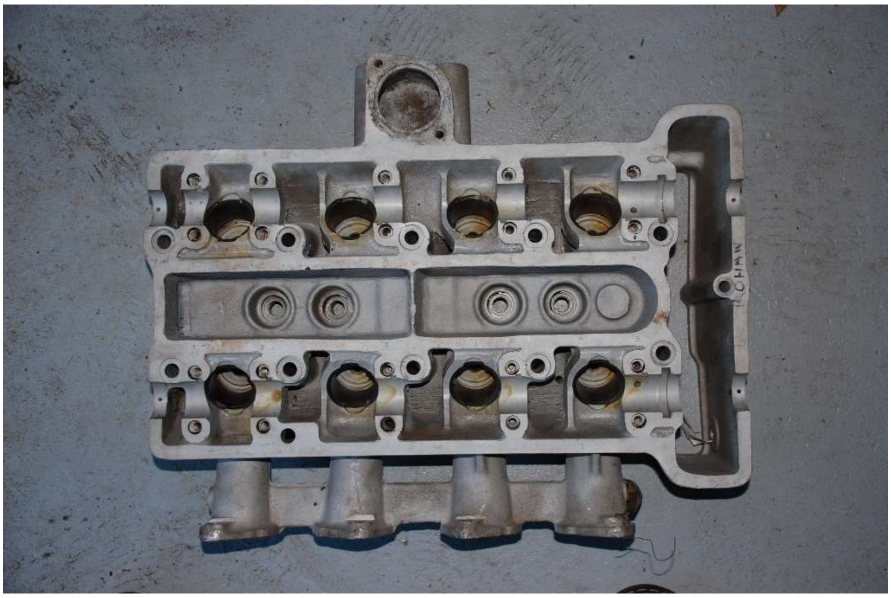
Modifications to a Twincam cylinder head are not the easiest thing to do and are expensive if you pay others to do it for that reason so you need to ensure you start with a good cylinder head.

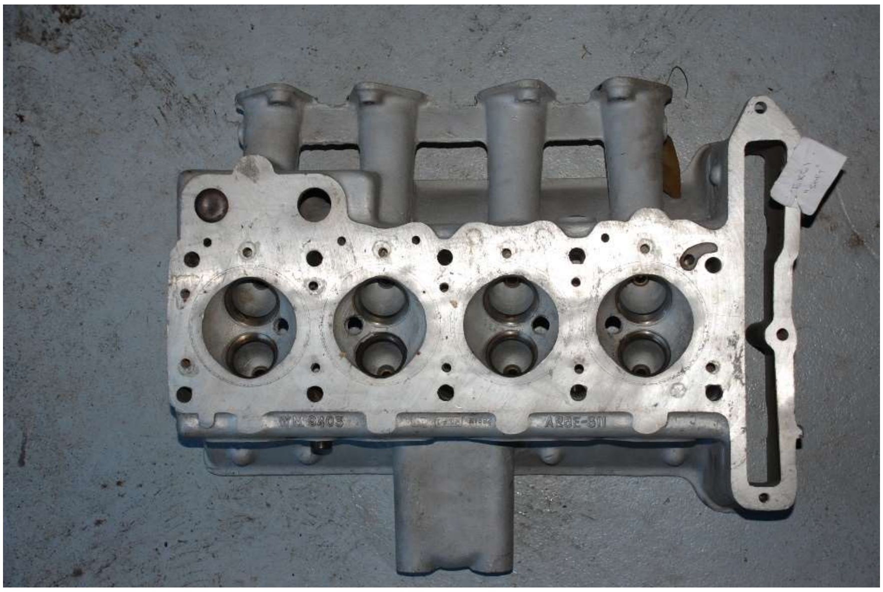
Finding a good used head can be challenging as many heads have had excessive machining done over the years or are softer than desirable due to age and overheating.

The heat treatment of the LM8 or LM25 alloys used in the Lotus Twincam cylinder heads (and other more modern heads also) leads to even normal heat levels slowly softening the head over time. This softening rate is exponential with temperature so a few overheating events can rapidly soften a head. Even without overheating an alloy head can become unacceptably soft just in normal operating temperature use over 50 years.

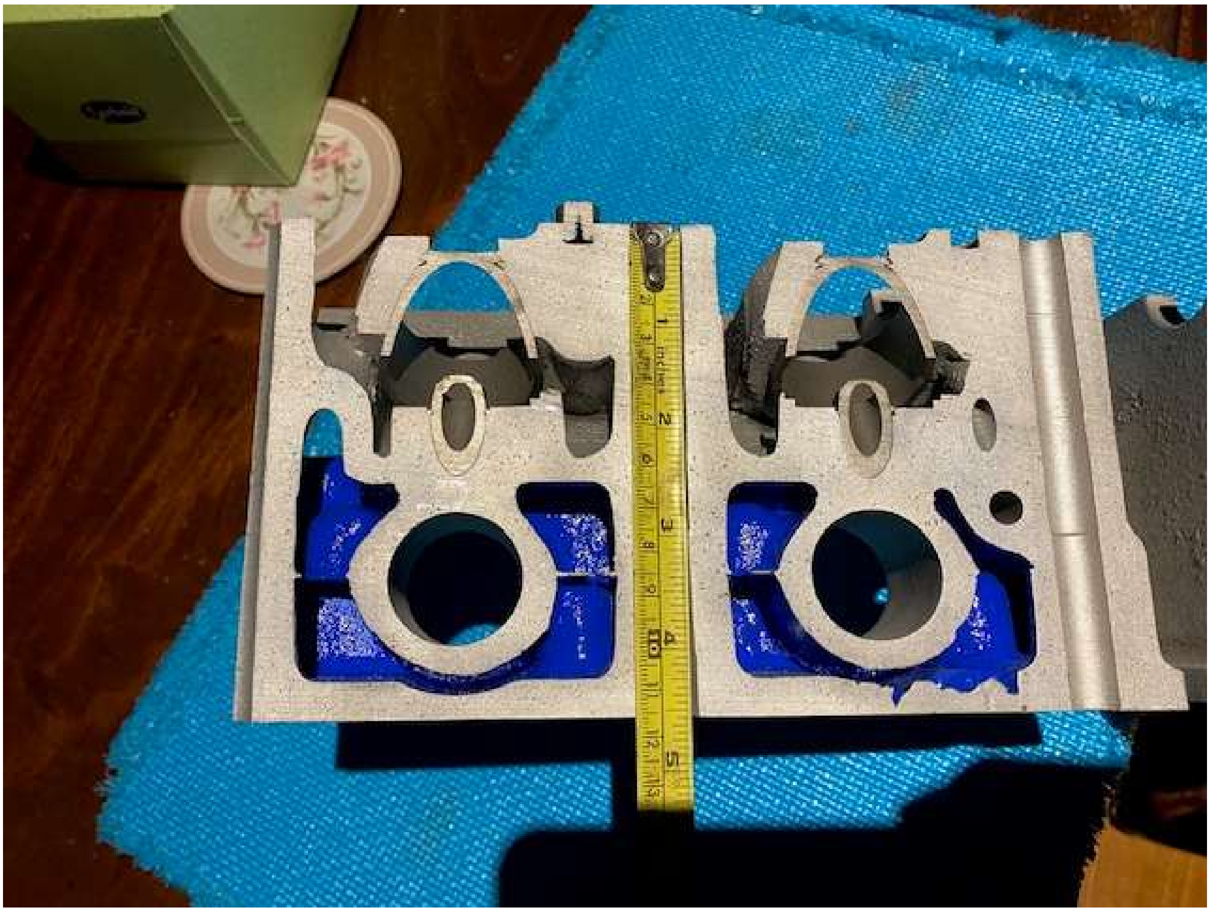
Modern alloy heads are typically 80 to 120 Brinell when new depending on how they are heat treated. Good condition used original Twincam heads I have measured in the 70 to 80 Brinell range. Twincam heads below 50 Brinell are borderline and heads in the 30 to 40 Brinell range will rapidly blow head gaskets. It is always wise to get a head hardness tested before doing extensive rebuild work on it and to start with the hardest head possible. I would never buy a used Twincam head without getting it hardness tested.

Photos of 30 to 40 Brinell hardness head. Note the recession if the head bolts into the top face of the head and the distinct impression of the gasket fire ring in the bottom face of the head.





Heads that have been machined significantly thinner than the standard 4.60 inches for the sprint head or 4.64 inches for the earlier heads can be used. I have seen heads successfully used where all the cast lettering on the bottom face has been machined off but that is pushing what desirable. The absolute minimum is reached when the water jacket under the exhaust port is broken into at around 4.45 inches. This can be less depending on casting irregularities, see the photo of a sectioned head below and note the irregularities in the right hand exhaust water jacket



When heads have had a lot machined off the bottom face to restore flatness then the top face may also have been machined and the cam bores re-machined to restore straightness also. All these dimensional changes due to historical maintenance machining can make building a modified head more challenging which makes starting with as close to original head as possible, desirable.

The easiest way to get a good cylinder head is to purchase one new from the SAS or QED in the UK or DBE in the USA. However the cost is high at around US$5000 for the bare head but it can be supplied ported to meet your needs and machined for the combustion chamber size desired within the original 41cc of a 4.64 inch head or the 37 cc of a 4.60 inch Sprint head.

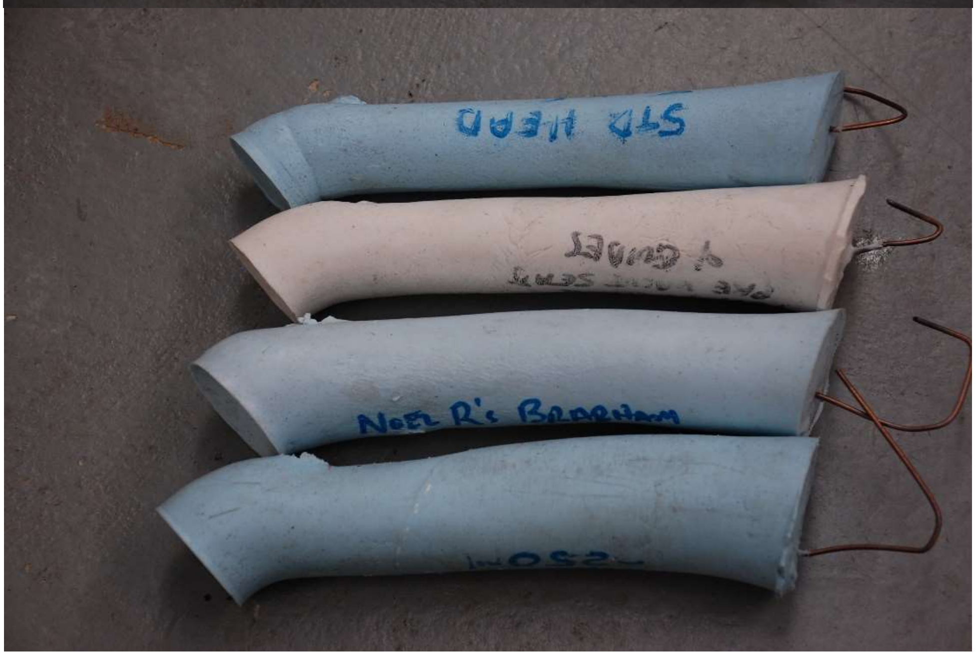
Another alternative is to get a modified Stromberg head from John McCoy at Omnitech. These are made by machining off the Stromberg inlets and bolting on a cast Weber style inlet. The removable inlet makes CNC porting of the head that John does easier with better outcomes. These heads with his race porting flow as well if not better than the original Hart heads or the latest new big inlet heads from the various suppliers. Low use excellent condition Stromberg heads are still available at a reasonable price having been removed early in their life and put into storage when replaced with Weber heads.

The final alternative is to port a good original head. This can be done by hand or John McCoy can CNC port an original head, others may also be able to do that also.

Below are photos of some inlet port castings indicating what’s possible.

The casting from top to bottom are:

1. Standard unmodified port
2. Modified original head port based on flow bench testing for 45 DCOE
3. Hart 416B port
4. McCoy converted head race porting from around 2010



David Vizard in his book “Tuning Twin Cam Fords” provided the details in the attached photo below.

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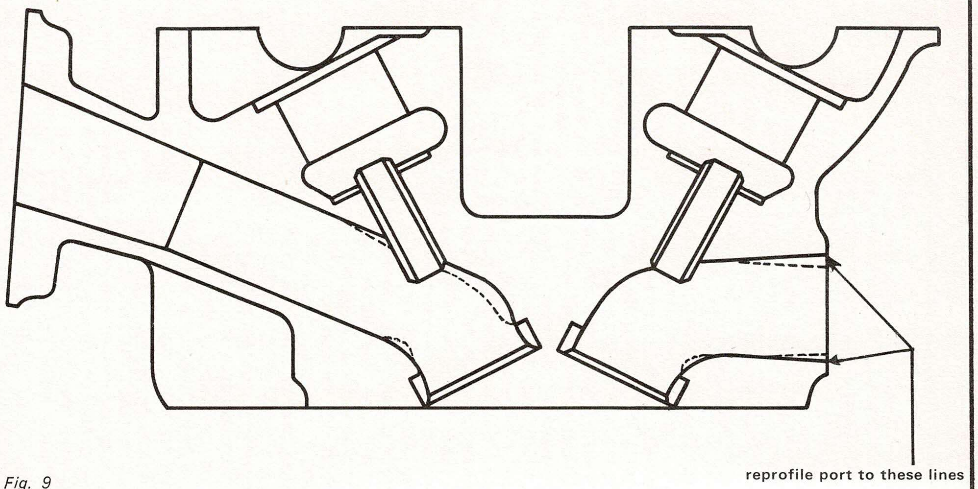

Fig. 9

Cross section of inlet (left) and exhaust ports (right)

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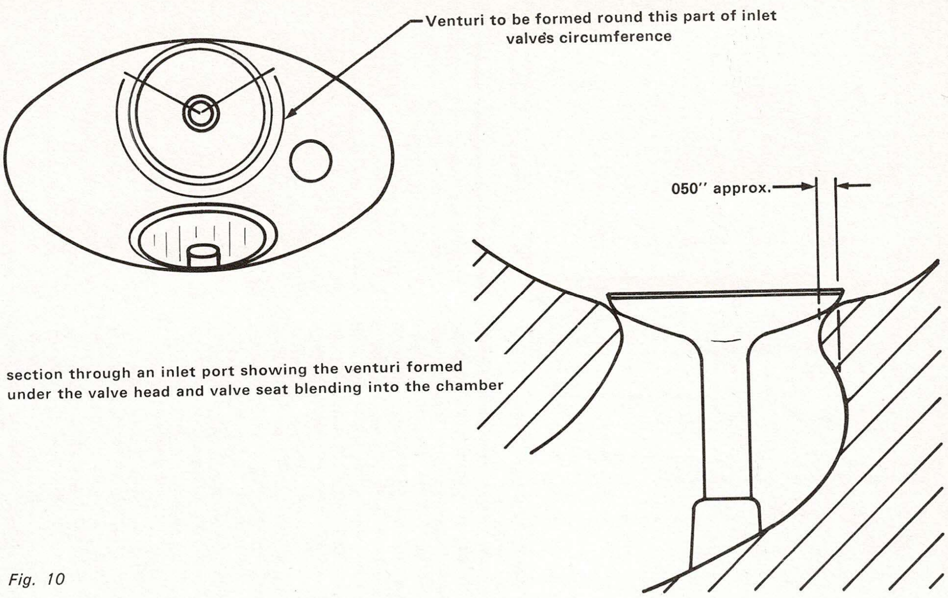

Fig. 10

Inlet valve port details

Porting on a modified head is the hardest thing to quantify unlike most other aspects of building a modified engine where precise measurements can be made to determine what is best.

Bigger is not always better. A standard original twin cam head had 29mm ports at the minimum diameter point. I measured one of my original heads that been race ported with a 33mm throat and the McCoy head I use now for racing has a more slightly oval shaped throat at around 34mm vertical and 35mm horizontal. There is a lot more than just the throat size when porting a head, but it gives some indication of the extent of the work that can be done.

It is important to get a porting job matched to a cam selection and the intended use of the engine. 1600cc engines I have built with the McCoy converted heads and short duration high lift cams have very good lowdown torque when used with 34mm or 36mm chokes in the carbs. 38mm chokes generate more top end power on the track but struggle to work well at more normal road engine speeds, though perhaps more time on the dyno could improve their low rpm performance.

A 1700 cc or 1760 cc or bigger engine should be even better at normal road engine speeds with greater airflow and higher port velocities and bigger capacity improving lower engine speed torque and performance for road use.

The chart below from Head Stud Services is flow bench data for one of my McCoy modified race heads with the port casting shown above.

Flow bench data is really a comparative exercise to be used as a head is being developed. Due to differences in flow bench setup it is difficult to use them as an absolute measure. Also head performance is influenced by many factors not tested on a flow bench such as port volume and pulsating flow / pressure wave behaviour with the pulsing of the intake and exhaust ports. However with this head they predicted it should achieve around 180 Hp when they tested it. On the Dyno it measured 181 Hp so not too bad in an absolute sense in this example at least.

Head flow measurements are done at differing pressure typically between 10 and 28 inches of water suction and reported in Cubic Feet per Minute (CFM). You need to check what it’s been done at when comparing head flow data from different sources. The conversion ratio for different test pressures assuming turbulent flow in the port which is the normal case is as below:

F1/F2= square root (P1/P2)

When corrected for the pressure difference in the tests below the McCoy and Hart heads flow the same at 0.450” lift with the McCoy heads flowing a bit better at lower lifts and the Hart head flowing a bit better at higher lifts

HEADSTUD DEVELOPMENT COMPANY P/L

(Inc. in Vic.) A.C.N. 050 578 375

31 CAPELLA CRESENT. MOORABBIN VIC 3189

Phone:(03) 9553 2517 Fax:(03) 9532 2485

25" H2O.

Name:	**16300 ROWHAN HODGES**										
Date:	16.11.2021										
Make:	**LOTUS TWIN CAM**										
Cyl: 4											
Intake	1.625 VALVE FLOWED THROUGH RAM TUBE										
First Flow											
Lift	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**
Range	48.4	101	101	201	201	201	201	201	201	201	201
Flow %	0.480	0.455	0.690	0.460	0.580	0.685	0.760	0.800	0.825	0.840	0.860
CFM	23.232	45.955	69.69	92.46	116.58	137.69	152.76	160.8	165.83	168.84	172.86
Mean CFM	**108.89**	**CFM**									
HP	25.3	50.0	75.8	100.5	126.7	149.7	166.1	174.8	180.3	183.5	187.9

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25" H2O

Exhaust	1.400 VALVE										
First Flow											
Lift	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**
Range	48.9	103	103	103	208	208	208	208	208	208	208
Flow %	0.420	0.400	0.580	0.702	0.415	0.460	0.490	0.520	0.550	0.580	0.600
CFM	20.538	41.2	59.74	72.306	86.32	95.68	101.92	108.16	114.4	120.64	124.8
Mean CFM	**78.809**	**CFM**									
Exh % flow	88.4	89.7	85.7	78.2	74.0	69.5	66.7	67.3	69.0	71.5	72.2

Some other head flow data for modified heads at different test pressure drop below . Unfortunately I don't have test data for a standard head but one day I will get it done on one of my spare heads. The flow of a standard head is approximately 2/3 of a ported full race head.

The data below is for an Original Hart head and for a McCoy modified head (Labelled Elan) done on the same test bench from a fellow Lotus racer.

Port Flow Analyzer v3.5 | Airflow Developments | This Report Printed:
Test: chris lotus 2valve twin cam | | 6:18 pm 04-15-14
Folder: English | Performance Trends (C) 2006 | Page: 1

Test Comments:

Report of:	Test Time		Tested at	Corr to	# Vlvs	Vlv Dia	Stem Dia	Port Area
All 2	10:38 am	Int:	28"	28.0"	1	1.652"	"	.00 sq in
Cylinders	04/15/2014	Exh:	28"	28.0"	1	1.405"	"	.00 sq in

HART.

Port	Lift	L/D	Corr CFM	VlvArea sq.in	CFM / sq.in	FlwArea sq.in	Flow Coef.	Valve Velocity	Port Velocity	% Exh/Int
Int #1	.000	.000	-.7	.000	.00	.000	.000	.0	.0	
Int #1	.100	.061	46.5	.519	89.67	.319	.615	215.2	.0	
Int #1	.150	.091	65.6	.778	84.32	.450	.579	202.4	.0	
Int #1	.200	.121	86.0	1.038	82.87	.590	.569	198.9	.0	
Int #1	.250	.151	111.1	1.297	85.63	.762	.588	205.5	.0	
Int #1	.300	.182	128.8	1.557	82.72	.884	.568	198.5	.0	
Int #1	.350	.212	147.5	1.816	81.20	1.012	.557	194.9	.0	
Int #1	.400	.242	164.7	2.076	79.35	1.130	.544	190.4	.0	
Int #1	.450	.272	181.9	2.143	84.85	1.248	.582	203.6	.0	
Int #1	.500	.303	193.5	2.143	90.29	1.328	.620	216.7	.0	
Int #1	.550	.333	201.8	2.143	94.17	1.385	.646	226.0	.0	
Exh #1	.000	.000	.0	.000	.00	.000	.000	.0	.0	
Exh #1	.100	.071	41.9	.441	95.01	.288	.652	228.0	.0	90.1
Exh #1	.150	.107	66.4	.662	100.23	.455	.688	240.5	.0	101.1
Exh #1	.200	.142	84.9	.883	96.13	.582	.660	230.7	.0	98.7
Exh #1	.250	.178	97.9	1.103	88.74	.672	.609	213.0	.0	88.1
Exh #1	.300	.214	108.3	1.324	81.81	.743	.561	196.4	.0	84.1
Exh #1	.350	.249	116.4	1.545	75.34	.799	.517	180.8	.0	78.9
Exh #1	.400	.285	121.4	1.550	78.31	.833	.537	187.9	.0	73.7
Exh #1	.450	.320	124.1	1.550	80.03	.851	.549	192.1	.0	68.2
Exh #1	.500	.356	126.8	1.550	81.79	.870	.561	196.3	.0	65.5
Exh #1	.550	.391	129.3	1.550	83.40	.887	.572	200.2	.0	64.1

ELAN.

Port	Lift	L/D	Corr CFM	VlvArea sq.in	CFM / sq.in	FlwArea sq.in	Flow Coef.	Valve Velocity	Port Velocity	% Exh/Int
Int #2	.000	.000	-.3	.000	.00	.000	.000	.0	.0	
Int #2	.100	.061	45.0	.519	86.70	.309	.595	208.1	.0	
Int #2	.150	.091	71.6	.778	92.03	.492	.631	220.9	.0	
Int #2	.200	.121	102.1	1.038	98.37	.701	.675	236.1	.0	
Int #2	.250	.151	128.0	1.297	98.63	.878	.677	236.7	.0	
Int #2	.300	.182	150.9	1.557	96.94	1.036	.665	232.7	.0	
Int #2	.350	.212	165.7	1.816	91.22	1.137	.626	218.9	.0	
Int #2	.400	.242	174.2	2.076	83.91	1.195	.576	201.4	.0	
Int #2	.450	.272	178.6	2.143	83.30	1.225	.572	199.9	.0	
Int #2	.500	.303	180.7	2.143	84.31	1.240	.578	202.4	.0	
Int #2	.550	.333	182.0	2.143	84.92	1.249	.583	203.8	.0	
Exh #2	.000	.000	.0	.000	.00	.000	.000	.0	.0	
Exh #2	.100	.071	39.3	.441	89.04	.270	.611	213.7	.0	87.3
Exh #2	.150	.107	58.8	.662	88.83	.404	.609	213.2	.0	82.1
Exh #2	.200	.142	78.4	.883	88.76	.538	.609	213.0	.0	76.7
Exh #2	.250	.178	93.3	1.103	84.54	.640	.580	202.9	.0	72.9
Exh #2	.300	.214	105.5	1.324	79.71	.724	.547	191.3	.0	69.9
Exh #2	.350	.249	114.2	1.545	73.95	.784	.507	177.5	.0	68.9
Exh #2	.400	.285	120.5	1.550	77.73	.827	.533	186.6	.0	69.2
Exh #2	.450	.320	124.7	1.550	80.44	.856	.552	193.1	.0	69.8
Exh #2	.500	.356	129.3	1.550	83.39	.887	.572	200.1	.0	71.5
Exh #2	.550	.391	133.2	1.550	85.93	.914	.590	206.2	.0	73.2