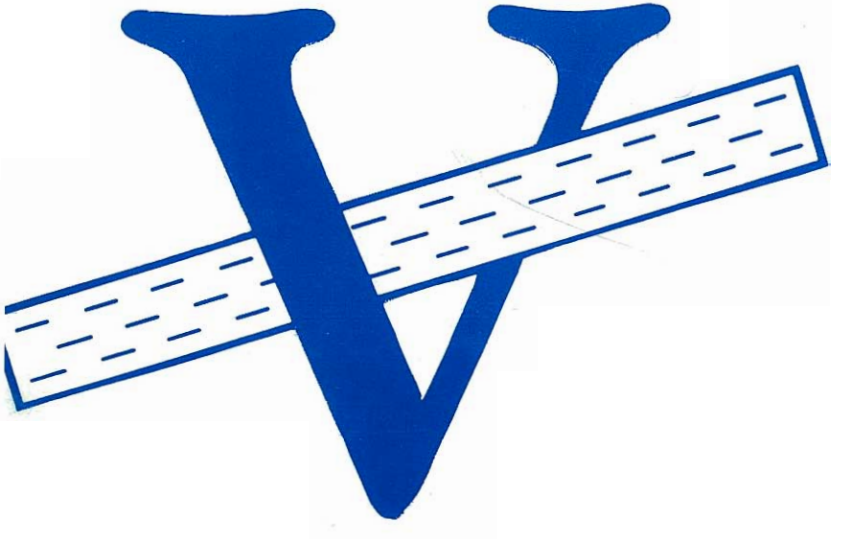
Valley Perforating Co.

LINER HANDBOOK



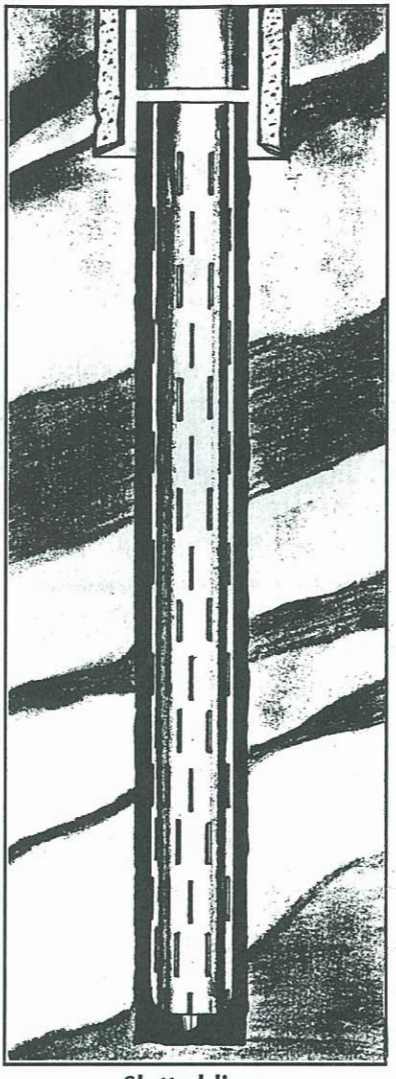
Licensed Under
API Spec 5CT

PREFACE

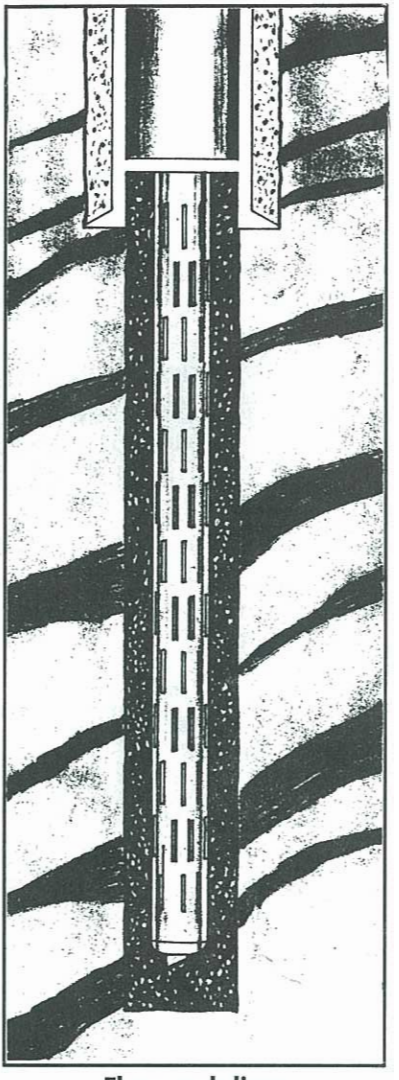
Sand and fine solids produced with oil and gas are major causes of uneconomic production, resulting in excessive expense as well as wear and down time on pumps, rods, tubing, traps and other equipment.

If knowledge of the physical properties of the solids to be controlled can be ascertained prior to completion (screen analyses from cores, bailings, etc.), an efficient pre-perforated oil well liner or casing can be designed to permit fluids to flow freely into the well with minimum draw-down while restraining the sand and solids from entering. Equally, if not more important, a properly designed pre-perforated or wirewrap liner offers a wide range choice of special completion techniques to enhance productivity while reducing or eliminating extraordinary and expensive well maintenance.

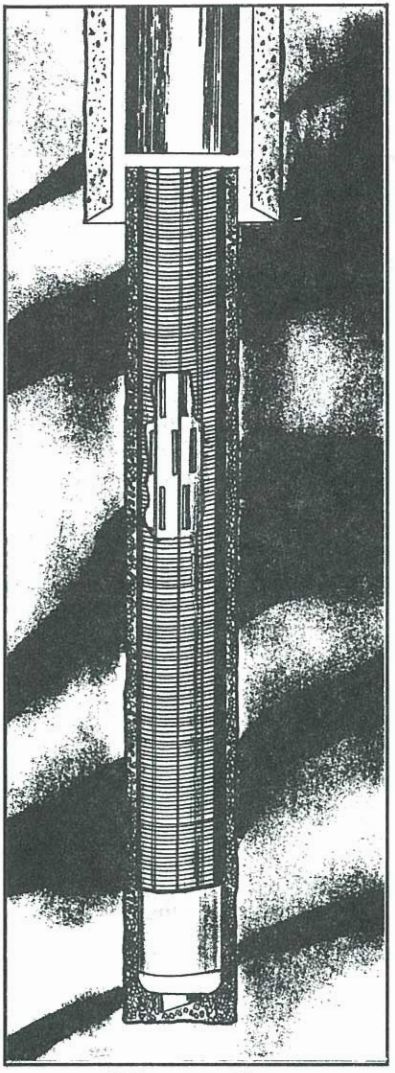
The purpose of this booklet is to discuss briefly the methods used in well completions and then to present in some detail data relative to pre-slotted liners.



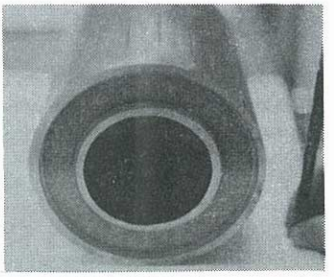
Slotted liner
in open hole



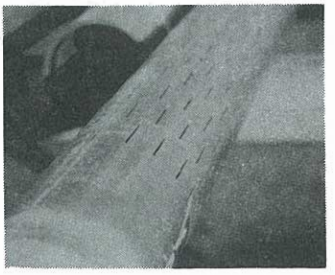
Flow pack liner
in open hole



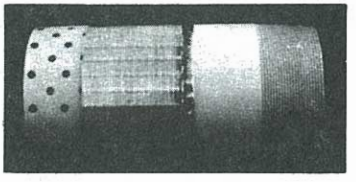
Wirewrap liner
in open hole or flow pack



Slotted prepack



Slotted Liner



Wirewrap liner utilizing
roundhole perforated basepipe

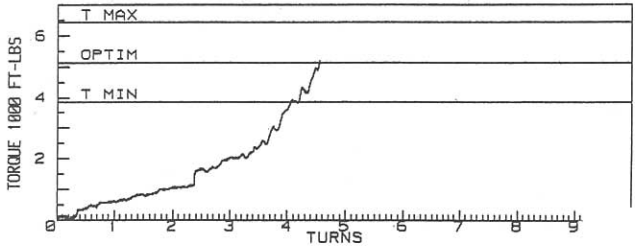
COUPLING / TOOL BUCKING UNIT

We have the capacity of handling all pipe sizes (2 3/8" thru 13 3/8") and torque capacities up to 36,000 Foot LB. Our facility is equipped with the Compu-Torque System which features a high speed computer which controls tong output to within plus or minus 10 ft. lbs., upgrading reading every 10 milliseconds. This program includes complete graphing capabilities in makeup or breakout mode.

COMPU-TORQUES SYSTEM:

This unique state-of-the-art system utilizes a high speed computer and interface system to monitor, control and record the spin-up / buck-up process for all types of threaded joints.

The operator inputs the joint data, make-up specifications and limits, thereafter, the computer provides high-speed monitoring of conditions as the joint is spun up and bucked up; shuts off the machine at precisely the right time, and verifies compliance with and/or deviations from the specifications.



THE KEY TO SAND CONTROL

The accepted key to controlling formation solids is the determination of the 10 percentile sand grain dimension in open hole and the 50 percentile grain dimension in gravel pack completions.

With this number and the data presented here the optimum well completion technique is easily and quickly determined.

The sequence in which the data is presented in this booklet permits a simple, step-by-step solution to the proper liner design with due consideration of most all alternatives.

QUICK REFERENCE INDEX

The design factors for controlling formation solids are discussed in a logical sequence:

SLOT SIZE DETERMINATION FROM TYLER SCREEN ANALYSES

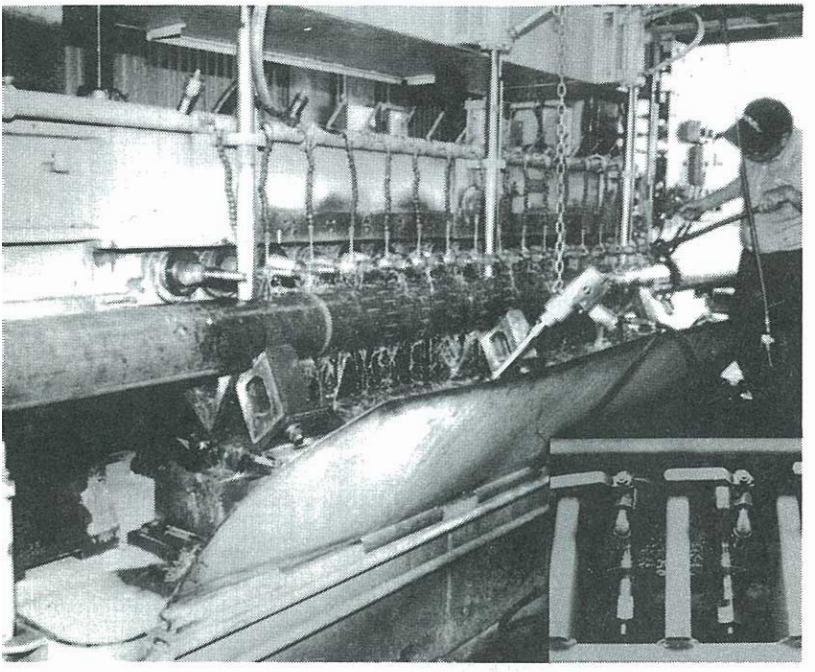
It is essential that the perforations be so formed that the sand grains will bridge across the outside of the opening in the pipe. The more common type of perforation consists of narrow slots cut with multi-spindle milling machines. The proper relation between slot width and grain size of the producing sand is usually best determined by the use of sand screen analyses based upon successive sieving through Tyler screens.

The Tyler Standard Screen Scale is simply a logarithmic graph on which the sand screen scale analysis is plotted. A sample of the scale is show in Figure A, on page 8.

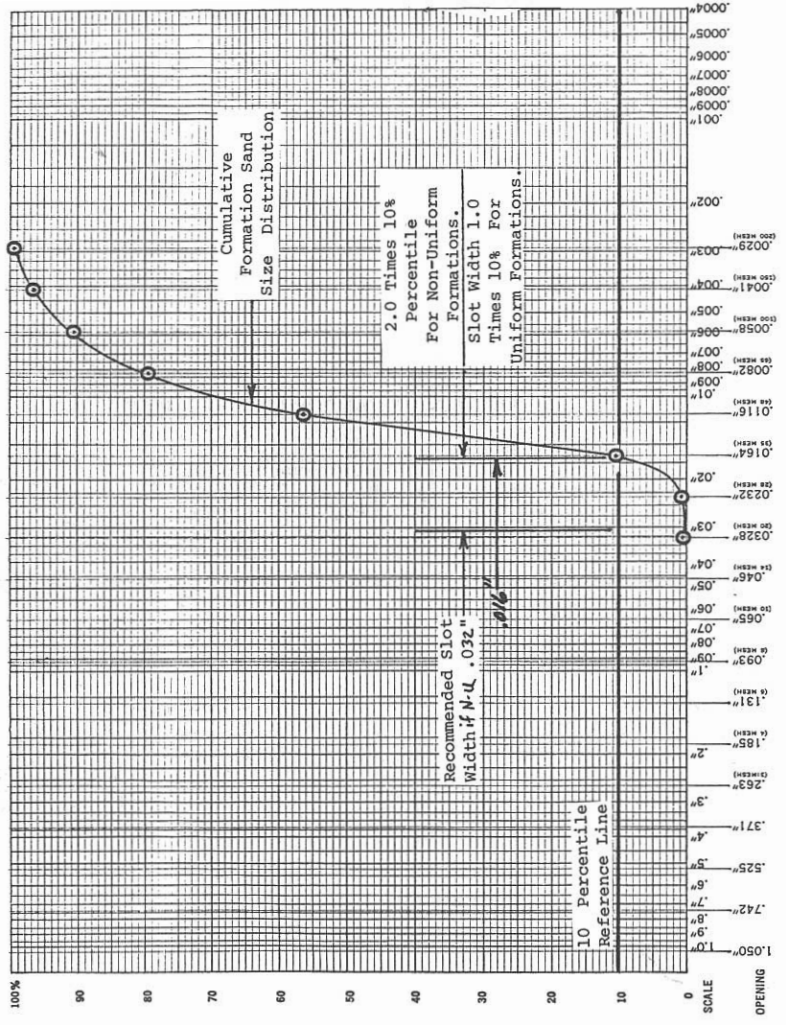
The usual method of determining grain-size distribution is to classify a weighed amount of the formation sand sample by screening through a series of nested screens of appropriate sizes. Formation sand for analysis may be obtained by ditch sampling or by bailing, if core samples are not available. The precentage of the total sample, by weight, retained on each screen provides an index of the grain-size distribution. Tyler standard screens used commonly range from 3 to 200 mesh. The results are best shown by plotting cumulative percentages by weight on a Tyler standard screen as shown in Figure 1.

Research and historical data indicate that best sand control results are generally obtained when the slot width is 1 or 2 times the grain size at the 10 percentile point of the Tyler screen, depending on uniformity of formations sands. For the example shown in Figures 1 and 2, Pages 8 and 10, a factor of 2.0 times the 10 percentile point was used to indicate a .032 slot width. Table B, on Pages 28 and 30, indicate standard slot widths.

Figure 2 on Page 10 presents a direct reading graph showing this 1 to 2 times relationship between formation grain size at the 10 percentile point and slot width size.



Special multispindle machine cuts many slots simultaneously. Note: Machine spindle designed on 6″ centers. See insert.

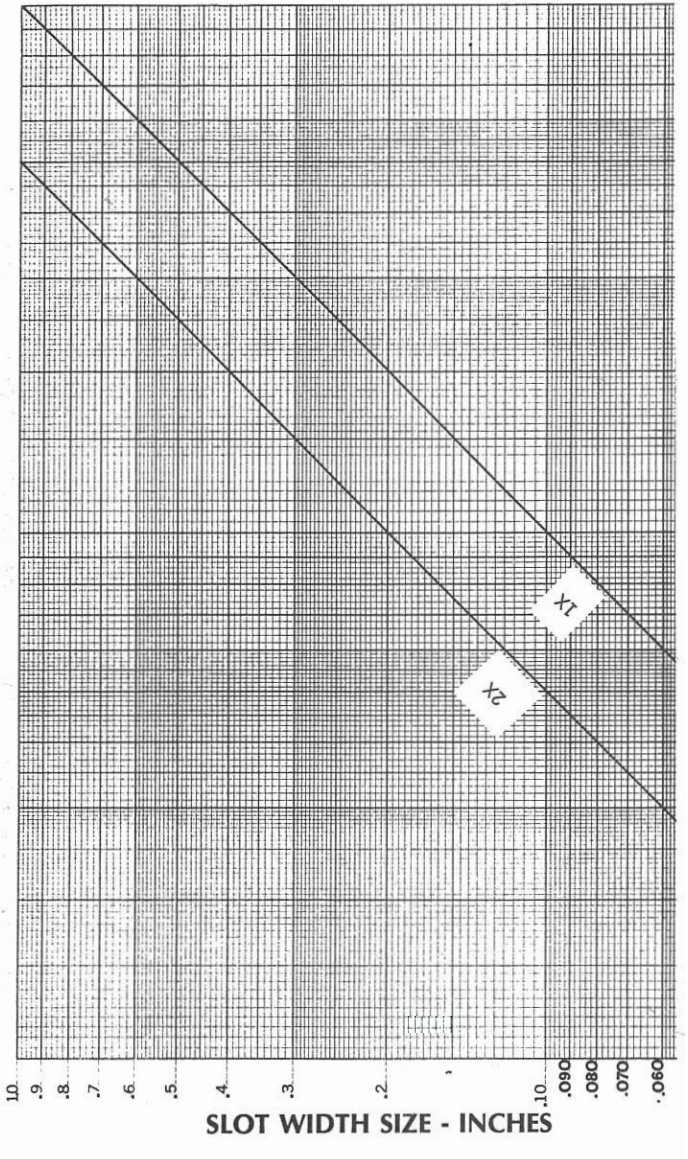


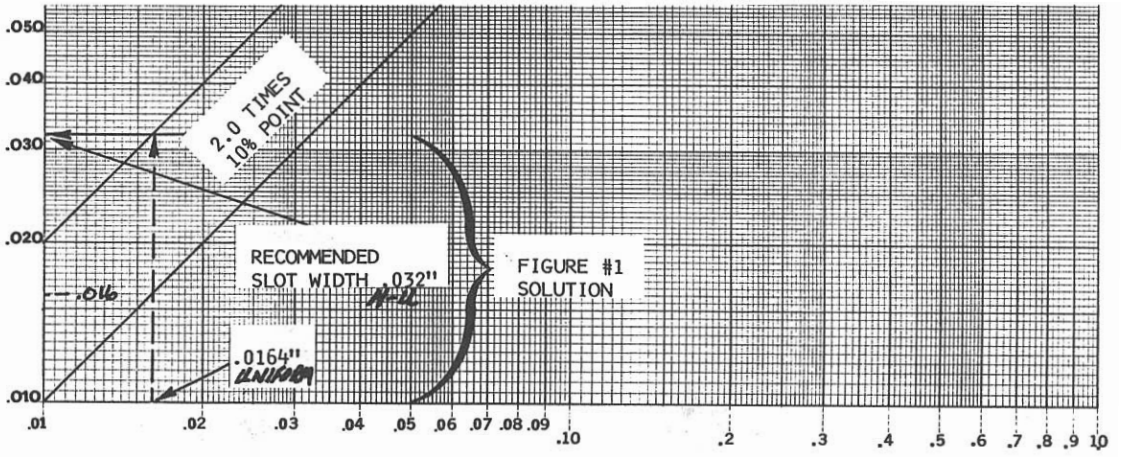
CUMULATIVE PERCENTAGES BY WEIGHT

	SCREEN SCALE RATIO 1.414													
	Openings		Tyler Mesh	U. S. No.	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	
	Inches	Milli-meters												
	1.050	26.67												
	.742	18.85												
	.525	13.33												
	.371	9.423												
	.263	6.680	3											
	.185	4.699	4	4										
	.131	3.327	6	6										
	.093	2.362	8	8										
	.065	1.651	10	12										
	.046	1.168	14	16										
	.0328	.833	20	20	0.3	0.3	0.3							
	.0232	.589	28	30	0.6	0.6	0.9							
	.0164	.417	35	40	9.8	9.8	10.7							
	.0116	.295	48	50	45.5	45.5	56.2							
	.0082	.208	65	70	23.3	23.3	79.5							
	.0058	.147	100	100	11.0	11.0	90.5							
	.0041	.104	150	140	6.4	6.4	96.9							
	.0029	.074	200	200	2.7	2.7	99.6							
Pass	.0029	.074	200	200	0.4	0.4	100.0							
				Totals,	100.0	100.0								

THE W. S. TYLER COMPANY, CLEVELAND 14, OHIO, U.S.A. 2-66

Fig 1. TYLER STANDARD SCREEN SCALE — EXAMPLE FOR SELECTION OF SLOT WIDTH.


1X
2X
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.090
.080
.070
.060
SLOT WIDTH SIZE - INCHES



Formation Sand Grain Size at 10 Percentile - Inches
Fig 2 - Quick Reference Graph for Selection of Slot Width when the 10 Percentile Figure is known.

CHOOSING A SLOT DESIGN

Straight Slot

Keystone Slot

This was the first type of slot manufactured. It has straight sides, equal width throughout the wall of the casing, and is more easily clogged by sand grains from the formation, than the Keystone slot.

As more and more slots became plugged with sand, a decreasing quantity of oil is obtained until finally a fraction of the oil available is produced.

It is essential that the slots be made so that the sand grains will bridge across the outside of the openings, but will not lodge within the openings themselves. The opening is narrower on the outside surface of the casing than on the inside, so that any grain of sand that enteres the slot will immediatley find enough clearance to pass completely through without clogging.

Slots formed in this way have a "V" cross section, up to and including 15° included angle. Experience has indicated, however, that a 6° included angle is adequate. The angle of undercut starts at the extreme outer edge of the casing. Thus the outer edge is amply backed up by a thick body of metal to resist erosion.

Since this undercut slot offers less resistance to clogging or plugging, it also offers less resistance to formation fluid flow, thus reducing the amount of pressure drop. This, of course, will consume less formation energy and result in higher ultimate recovery.

NOTE: Straight slot capability $\geq$ .012"
Keystone slot capability $\geq$ .025"

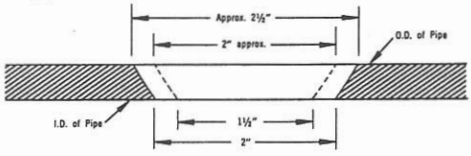
CHOOSING A PERFORATING PATTERN

Pipe is slotted with an even number of rows unless otherwise specified. This makes it possible to stagger the rows in order to preserve a greater portion of the original strength of the pipe and to secure an even distribution of slots over the surface of the pipe for more efficient drainage.

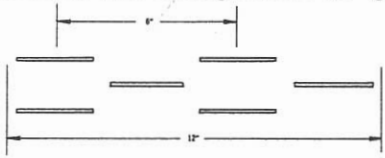
Usual practices are:

1½" length slots (or I.D.) for slot widths 0.030"
2" length slots (on I.D.) for slot width greater than 0.030"
All slots are spaced on 6" longitudinal centers

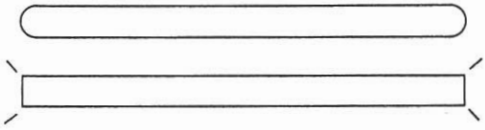
Typical Slot Cross-Section (Longitudinal)



Typical Vertical Slot Configuration (Longitudinal)



With Valley Perforating you have a choice of slots cut with either radial (rounded) or square ends. Rounded corners prevent high stress concentrations at the ends of each slot and reduce stress corrosion problems.



DETERMINATION OF NUMBER OF SLOTS PER FOOT OF PIPE

The number of slots per foot is determined by calculating the number required to achieve about 3% open area of the outer surface of the pipe to be perforated.

The following formula and example illustrate how to determine the number of slots per foot.

Formula: $$\text{No. slots / ft} = \frac{AC}{WL}$$

Where:

Data from Table A — A = O.D. surface area per foot of pipe (Sq. In./Ft.)

Data from customer — C = Desired percent open area

Data from Tyler Sand Analysis — W = Slot width in thousands of an inch

Standard practice — L = Slot length measured on I.D. in inches

NOTE: See Table B, C and D for Quick Reference Tabulations

Example: A = 207.3 sq.in./ft. (5½" O.D.)
C = 2.78 percent open area
W = .060" slot width
L = 2" slot length on I.D.

$$\text{No. slots/ft.} = \frac{(207.3)\ (.0278)}{(.060)\ \ (2)} = 48$$

Important Note:

On 6" longitudinal centers, the NUMBER OF SLOTS PER FOOT IS ALWAYS TWICE THE NUMBER OF ROWS OF SLOTS AROUND THE CIRCUMFERENCE. Thus, the 48 slots per foot, in the example, result in 24 rows as a specification.

CHOOSING A GRAVEL PACK LINER

In some areas it is impossible to control sand intrusion by slotted liners because of formation sand characteristics. When the fine sands will not bridge across the slots or the slot width becomes impractically small, another solution is necessary.

To prevent the removal of sand from the oil bearing strata which can bring about the creation of cavities, sloughing, shutting off of production, even collapse of the liner, gravel packing offers a solution to extend the economic productive life of oil wells.

Valley Perforating offers the following methods for sand control.

FLOW PACK

This method uses a centralized liner with slot widths based on analysis of well sands, around which, after installation, gravel is placed by gravity, pumping, etc. to fill the annulus. This method is effective only if the entire annular area is filled; it does offer more support to the walls of the bore hole in that there is, theoretically, no annular space unfilled with selected sands or gravels. Large hole diameters are desirable - mainly to insure that gravel or sand completely surrounds the slotted inner liner, leaving no voids. Careful centralizing of the slotted pipe, back-washing, hole enlargement, and provision for an extra reservoir of sand or gravel are additional expenses necessary for successful jobs.

NOTE: Refer to Table E for specificiations on gravel sizes.

PREPACK

The inner liner is designed with a slot width small enough to prevent any movement of pre-pack gravel particles. Concentric with the inner liner and supported on it by spacing guides to an outer jacket of liner with approximately 30% increased inlet area. Gravel of appropriate size is compacted within the annular space between the inner liner and the outer jacket. Usually the gravel sheath is about ½" to ¾ " thick, and is compacted by mechanical vibrators which assure minimum porosity. Pre-packed liners, which can be made in any length up to 43 feet, are durable and can be handled as normal liner materials.

WIRE WRAPPED OIL WELL SCREEN

A wire wrapped screen surrounded by a gravel pack is another widely used sand control method. All precautions used with a conventional flow pack liner apply. Although slotting capabilities are as low as .012", screen slot sizes offer a greater open area, smaller slot capabilities, but at an increased cost. The screen will provide an unobstructed flow path for the produced fluid while retaining the gravel. Wire wrap screens have had considerable success in open hole completions. Screens can be manufactured using either stainless or low carbon steel depending on customer requirements. Our plant has the capability to provide either base pipe slotting (.250") or round hole perforating with 1/4", 5/16", 3/8", 1/2" holes.

OPEN AREA WITH ROUND HOLE PERFORATING

No. of holes per ft. of pipe	Diam. of each hole-in.	Total area of holes Sq. in. ft.
72	1/4	3.53
72	1/4	3.53
60	5/16	4.60
60	5/16	4.60
72	5/16	5.52
84	5/16	6.44
84	5/16	6.44
96	3/8	10.60
108	3/8	11.93

No. of holes per ft. of pipe	Diam. of each hole-in.	Total area of holes Sq. in. ft.
108	1/2	21.21
120	1/2	23.56
144	1/2	28.27
156	1/2	30.63
168	1/2	32.99
180	1/2	35.34
192	1/2	37.70
204	1/2	40.06
264	1/2	51.84

DETERMINING SLOT WIDTH / GRAVEL SIZE

To be effective in sand screening, it is essential that the perforated liner be completely enveloped through the producing formation with a gravel sheath of suitable thickness. In theory a gravel pack thickness of 3 to 5 gravel grains would be sufficient, but practically, a gravel pack should be at least 3/4" in cased hole and greater than 2" in open hole. Effective sand screening also demands that the perforations in the liner be of such size and so compacted as to permit virtually no sand particles to pass into the well with the formation fluids. The coarser sand particles must bridge over the openings between the gravel particles at or near the sand-gravel interface. These coarse sand particles in turn serve as a barrier for finer sand grains and in time a combination of gravel sand is built up.

The size of the gravel particles should be proportioned to the size of the sand particles to be restrained. Through research and practical experience, it has been found best to make a Tyler screen analyses of a representative sample (the best of which is a full diameter core) of the reservoir sand, plotting the results on a cumulative weight percentage graph. Current practices utilize Saucier's Criterion (Saucier, R.J., "Considerations in Gravel Pack Design", J. Pet. Tech., February 1974, p 205.) in which:

$$5\, d_{50} \leq D_{50} \leq 6\, d_{50}$$

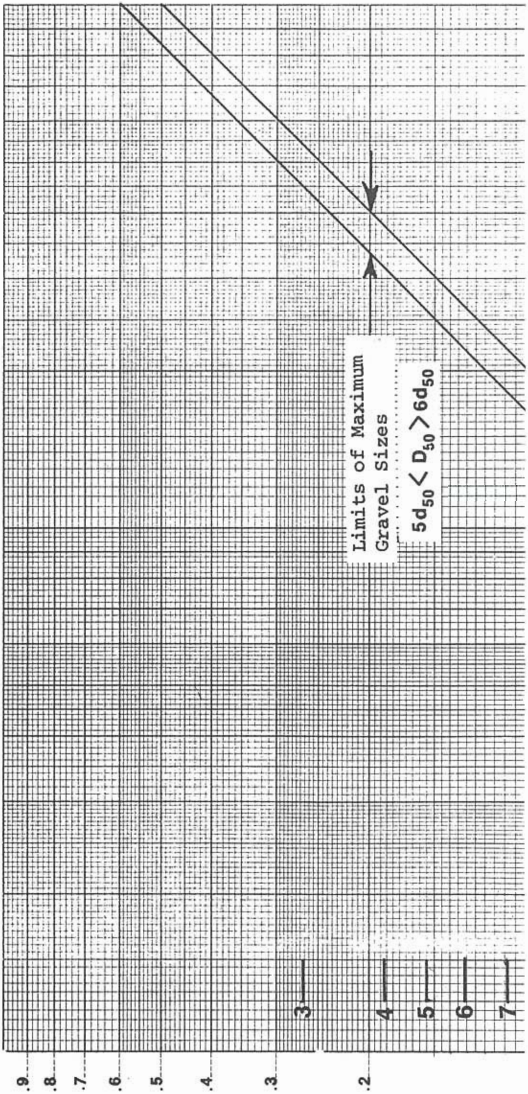
Where D_{50} is the median gravel grain diameter defined analogously to the median formation grain size, d_{50}. In general, gravel should be sized based on the d_{50} of the smallest formation sand present in any interval to the produced. More complete information can be made available upon request to Valley Perforating or direct from the API Recommended Practice on Gravel Pack Materials.

After screening and plotting the analyses of the formation sand to be controlled, use the example shown on graphs of Figures 3 and 4 following, to make your selection.

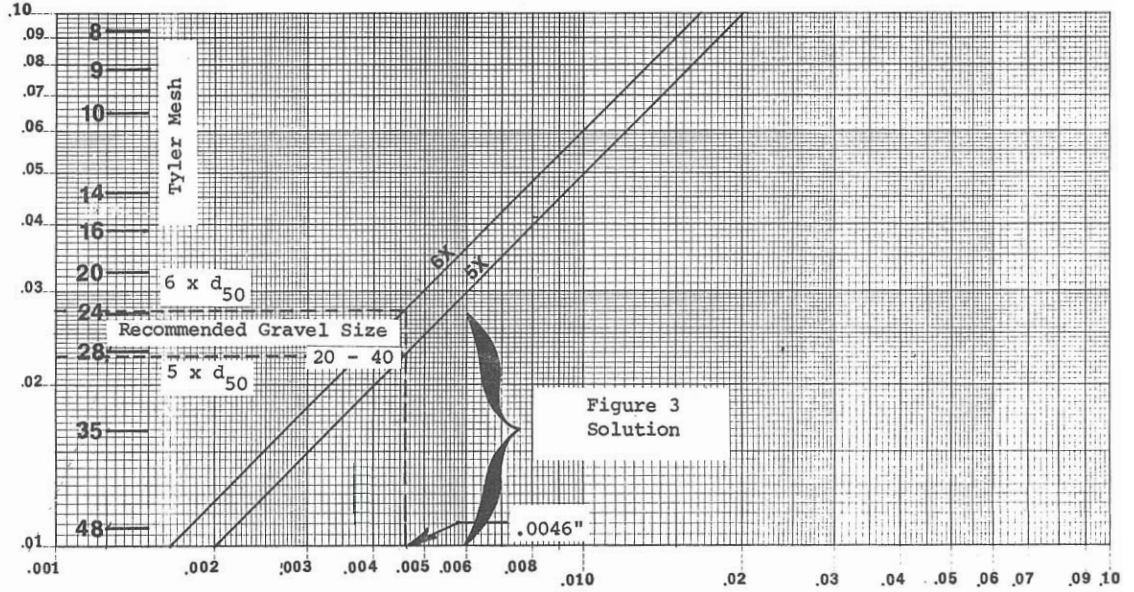
NOTE: Refer to TABLE E for specifications on gravel sizes.

	SCREEN SCALE RATIO 1.414				Formation Sand						20-40 Gravel Pack			
	Openings		Tyler Mesh	U. S. No.	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	
	Inches	Milli-meters												
	1.050	26.67												
	.742	18.85												
	.525	13.33												
	.371	9.423												
	.263	6.680	3											
	.185	4.699	4	4										
	.131	3.327	6	6										
	.093	2.362	8	8										
	.065	1.651	10	12										
	.046	1.168	14	16							.2	.2	.2	
	.0328	.833	20	20							2.6	2.6	2.8	
	.0232	.589	28	30							70.0	70.0	72.8	
	.0164	.417	35	40	0.0	0.0	0.0				26.2	26.2	99.0	
	.0116	.295	48	50	8.5	8.5	8.5				1.0	1.0	100.0	
	.0082	.208	65	70	12.5	12.5	21.							
	.0058	.147	100	100	13.3	13.3	34.3							
	.0041	.104	150	140	38.4	38.4	72.7							
	.0029	.074	200	200	27.3	27.3	100.0							
Pass	.0029	.074	200	200										
				Totals,	100.0	100.0								

Tyler Standard Screen Scale - Example for Selection of Gravel Pack Sizes

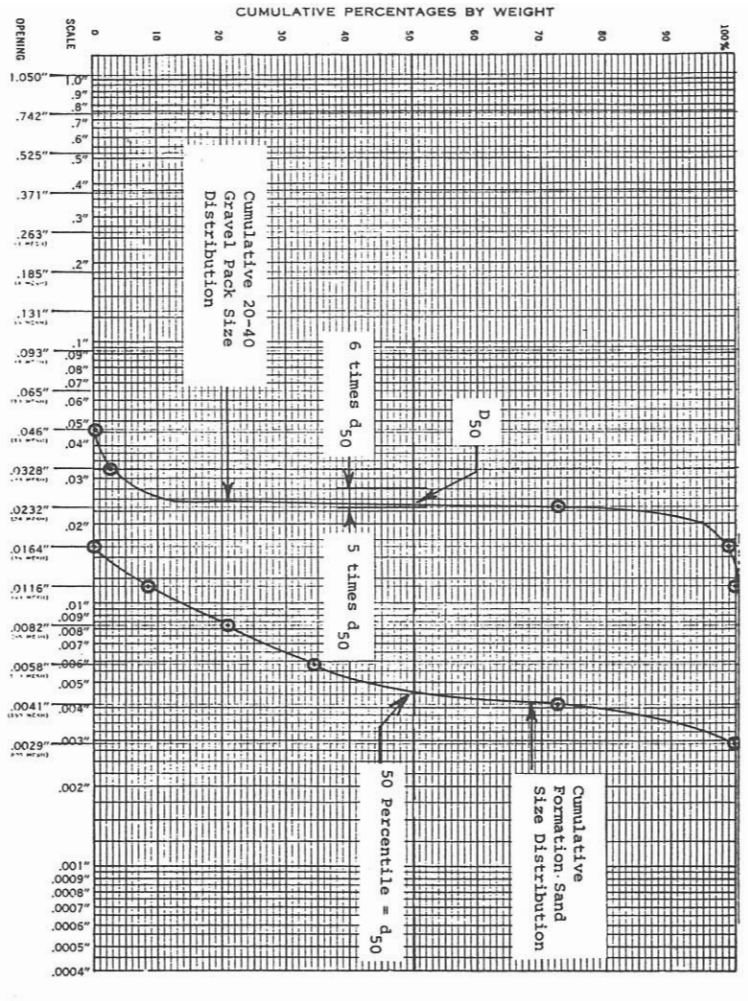


FLOW PACK GRAVEL SIZES - INCHES



Formation Sand Grain Size at 50 Percentile - Inches

Fig 4. Quick Reference Graph for Selection of Flow Pack Gravel Size.



CUMULATIVE PERCENTAGES BY WEIGHT

TABLE A
PIPE SURFACE AREA/LINEAL FEET IN SQ. INCHES

Liner, O.D. inches	Sq. in./ft.	Liner, O.D. inches	Sq. in./ft.
4	150.7968	5 - 1/2	207.3456
4 - 1/2	169.6464	6 - 5/8	249.7572
4 - 3/4	179.0712	7	263.8944
5	188.4960	8 - 5/8	325.1556

After the correct gravel pack size distribution has been made, we determine the slot or screen width as .005" to .010" less than the smallest gravel size. In our sample we choose .020".

TABLE B
KEYSTONE AND STRAIGHT SLOTS
SQUARE INCHES OF INLET AREA PER FOOT OF PIPE
SLOTS 2″ LONG, SPACED ON 6″ CENTERS

Number of Rows	Number Slots Per Ft.	Lineal Inches Per Ft.	Slot Width in Thousandths of an Inch									
			20	30	40	50	60	70	80	100	120	125
	1	2	.04	.06	.08	.10	.12	.14	.16	.20	.24	.25
2	4	8	.16	.24	.32	.40	.48	.56	.64	.80	.96	1.00
4	8	16	.32	.48	.64	.80	.96	1.12	1.28	1.60	1.92	2.00
6	12	24	.48	.72	.96	1.20	1.44	1.68	1.92	2.40	2.88	3.00
8	16	32	.64	.96	1.28	1.60	1.92	2.24	2.56	3.20	3.84	4.00
10	20	40	.80	1.20	1.60	2.00	2.40	2.80	3.20	4.00	4.80	5.00
12	24	48	.96	1.44	1.92	2.40	2.88	3.36	3.84	4.80	5.76	6.00
14	28	56	1.12	1.68	2.24	2.80	3.36	3.92	4.48	5.60	6.72	7.00
16	32	64	1.28	1.92	2.56	3.20	3.84	4.48	5.12	6.40	7.68	8.00

18	36	72	1.44	2.16	2.88	3.60	4.32	5.04	5.76	7.20	8.64	9.00
20	40	80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	8.00	9.60	10.00
22	44	88	1.76	2.64	3.52	4.40	5.28	6.16	7.04	8.80	10.56	11.00
24	48	96	1.92	2.88	3.84	4.80	5.76	6.72	7.68	9.60	11.52	12.00
26	52	104	2.08	3.12	4.16	5.20	6.24	7.28	8.32	10.40	12.48	13.00
28	56	112	2.24	3.36	4.48	5.60	6.72	7.84	8.96	11.20	13.44	14.00
30	60	120	2.40	3.60	4.80	6.00	7.20	8.40	9.60	12.00	14.40	15.00
32	64	128	2.56	3.84	5.12	6.40	7.68	8.96	10.24	12.80	15.36	16.00
34	68	136	2.72	4.08	5.44	6.80	8.16	9.52	10.88	13.60	16.32	17.00
36	72	144	2.88	4.32	5.76	7.20	8.64	10.08	11.52	14.40	17.28	18.00
38	76	152	3.04	4.56	6.08	7.60	9.12	10.64	12.16	15.20	18.24	19.00
40	80	160	3.20	4.80	6.40	8.00	9.60	11.20	12.80	16.00	19.20	20.00
42	84	168	3.36	5.04	6.72	8.40	10.08	11.76	13.44	16.80	20.16	21.00
44	88	176	3.52	5.28	7.04	8.80	10.56	12.32	14.08	17.60	21.12	22.00
46	92	184	3.68	5.52	7.36	9.20	11.04	12.88	14.72	18.40	22.08	23.00
48	96	192	3.84	5.76	7.68	9.60	11.52	13.44	15.36	19.20	23.04	24.00
50	100	200	4.00	6.00	8.00	10.00	12.00	14.00	16.00	20.00	24.00	25.00

TABLE B (con't.)
KEYSTONE AND STRAIGHT SLOTS
SQUARE INCHES OF INLET AREA PER FOOT OF PIPE
SLOTS 2″ LONG, SPACED ON 6″ CENTERS

Number Rows	Number Slots Per Ft.	Lineal Inches Per Ft.	Slot Width in Thousandths of an Inch										
			140	150	160	180	187	200	250	300	375	400	500
	1	2	.28	.30	.32	.36	.37	.40	.50	.60	.75	.80	1.00
2	4	8	1.12	1.20	1.28	1.44	1.50	1.60	2.00	2.40	3.00	3.20	4.00
4	8	16	2.24	2.40	2.56	2.88	3.00	3.20	4.00	4.80	6.00	6.40	8.00
6	12	24	3.36	3.60	3.84	4.32	4.50	4.80	6.00	7.20	9.00	9.60	12.00
8	16	32	4.48	4.80	5.12	5.76	6.00	6.40	8.00	9.60	12.00	12.80	16.00
10	20	40	5.60	6.00	6.40	7.20	7.50	8.00	10.00	12.00	15.00	16.00	20.00
12	24	48	6.72	7.20	7.68	8.64	9.00	9.60	12.00	14.40	18.00	19.20	24.00
14	28	56	7.84	8.40	8.96	10.08	10.50	11.20	14.00	16.80	21.00	22.40	28.00
16	32	64	8.96	9.60	10.24	11.52	12.00	12.80	16.00	19.20	24.00	25.60	32.00

18	36	72	10.08	10.80	11.52	12.96	13.50	14.40	18.00	21.60	27.00	28.80	36.00
20	40	80	11.20	12.00	12.80	14.40	15.00	16.00	20.00	24.00	30.00	32.00	40.00
22	44	88	12.32	13.20	14.08	15.84	16.50	17.60	22.00	26.40	33.00	35.20	44.00
24	48	96	13.44	14.40	15.36	17.28	18.00	19.20	24.00	28.80	36.00	38.40	48.00
26	52	104	14.56	15.60	16.64	18.72	19.50	20.80	26.00	31.20	39.00	41.60	52.00
28	56	112	15.68	16.80	17.92	20.16	21.00	22.40	28.00	33.60	42.00	44.80	56.00
30	60	120	16.80	18.00	19.20	21.60	22.50	24.00	30.00	36.00	45.00	48.00	60.00
32	64	128	17.92	19.20	20.48	23.04	24.00	25.60	32.00	38.40	48.00	51.20	64.00
34	68	136	19.04	20.40	21.76	24.48	25.50	27.20	.34.00	40.80	51.00	54.40	68.00
36	72	144	20.16	21.60	23.04	25.92	27.00	28.80	36.00	43.20	54.00	57.60	72.00
38	76	152	21.28	22.80	24.32	27.36	28.50	30.40	38.00	45.60	57.00	60.80	76.00
40	80	160	22.40	24.00	25.60	28.80	30.00	32.00	40.00	48.00	60.00	64.00	80.00
42	84	168	23.52	25.20	26.88	30.24	31.50	33.60	42.00	50.40	63.00	67.20	84.00
44	88	176	24.64	26.40	28.16	31.68	33.00	35.20	44.00	52.80	66.00	70.40	88.00
46	92	184	25.76	27.60	29.44	33.12	34.50	36.80	46.00	55.20	69.00	73.60	92.00
48	96	192	26.88	28.80	30.72	34.56	36.00	38.40	48.00	57.60	72.00	76.80	96.00
50	100	200	28.00	30.00	32.00	36.00	37.50	40.00	50.00	60.00	75.00	80.00	100.00

TABLE C
KEYSTONE AND STRAIGHT SLOTS
PERCENT OPEN AREA PER LINEAL FOOT OF PIPE
SLOTS 2″ LONG, SPACED ON 6″ CENTERS
PIPE SIZE — 5 INCHES O.D.

Number of Rows	Slot Width in Thousandths of an Inch								
	40	60	80	100	125	140	160	180	250
6	0.51	0.76	1.02	1.27	1.59	1.78	2.04	2.29	3.18
8	0.68	1.02	1.36	1.70	2.12	2.38	2.72	3.06	4.24
10	0.85	1.27	1.70	2.12	2.65	2.97	3.40	3.82	5.31
12	1.02	1.53	2.04	2.55	3.18	3.57	4.07	4.58	6.37
14	1.19	1.78	2.38	2.97	3.71	4.16	4.75	5.35	7.43

16	1.36	2.04	2.72	3.40	4.24	4.75	5.43	6.11	8.49
18	1.53	2.29	3.06	3.82	4.77	5.35	6.11	6.88	9.55
20	1.70	2.55	3.40	4.24	5.31	5.94	6.79	7.64	10.61
22	1.87	2.80	3.73	4.67	5.84	6.54	7.47	8.40	11.67
24	2.04	3.06	4.07	5.09	6.37	7.13	8.15	9.17	12.73
26	2.21	3.31	4.41	5.52	6.90	7.72	8.83	9.93	13.79
28	2.38	3.56	4.75	5.94	7.43	8.32	9.51	10.70	14.85
30	2.55	3.82	5.09	6.37	7.96	8.91	10.19	11.46	15.92
32	2.72	4.07	5.43	6.79	8.49	9.51	10.86	12.22	16.98

TABLE C
KEYSTONE AND STRAIGHT SLOTS
PERCENT OPEN AREA PER LINEAL FOOT OF PIPE
SLOTS 2″ LONG, SPACED ON 6″ CENTERS
PIPE SIZE — 5½ INCHES O.D.

Number of Rows	Slot Width in Thousandths of an Inch								
	40	60	80	100	125	140	160	180	250
6	0.46	0.69	0.93	1.16	1.45	1.62	1.85	2.08	2.89
8	0.62	0.93	1.23	1.54	1.93	2.16	2.47	2.78	3.86
10	0.77	1.16	1.54	1.93	2.41	2.70	3.09	3.47	4.82
12	0,93	1.39	1.85	2.31	2.89	3.24	3.70	4.17	5.79
14	1.08	1.62	2.16	2.70	3.38	3.78	4.32	4.86	6.75

16	1.23	1.85	2.47	3.09	3.86	4.32	4.94	5.56	7.72
18	1.39	2.08	2.78	3.47	4.34	4.86	5.56	6.25	8.68
20	1.54	2.31	3.09	3.86	4.82	5.40	6.17	6.94	9.65
22	1.70	2.55	3.40	4.24	5.31	5.94	6.79	7.64	10.61
24	1.85	2.78	3.70	4.63	5.79	6.48	7.41	8.33	11.57
26	2.01	3.01	4.01	5.02	6.27	7.02	8.03	9.03	12.54
28	2.16	3.24	4.32	5.40	6.75	7.56	8.64	9.72	13.50
30	2.31	3.47	4.63	5.79	7.23	8.10	9.26	10.42	14.47
32	2.47	3.70	4.94	6.17	7.72	8.64	9.88	11.11	15.43

TABLE C
KEYSTONE AND STRAIGHT SLOTS
PERCENT OPEN AREA PER LINEAL FOOT OF PIPE
SLOTS 2″ LONG, SPACED ON 6″ CENTERS
PIPE SIZE — 6-5/8 INCHES O.D.

Number of Rows	Slot Width in Thousandths of an Inch								
	40	60	80	100	125	140	160	180	250
6	0.38	0.58	0.77	0.96	1.20	1.35	1.54	1.73	2.40
8	0.51	0.77	1.02	1.28	1.60	1.79	2.05	2.31	3.20
10	0.64	0.96	1.28	1.60	2.00	2.24	2.56	2.88	4.00
12	0.77	1.15	1.54	1.92	2.40	2.69	3.07	3.46	4.80
14	0.90	1.35	1.79	2.24	2.80	3.14	3.59	4.04	5.61

16	1.02	1.54	2.05	2.56	3.20	3.59	4.10	4.61	6.41
18	1.15	1.73	2.31	2.88	3.60	4.04	4.61	5.19	7.21
20	1.28	1.92	2.56	3.20	4.00	4.48	5.12	5.77	8.01
22	1.41	2.11	2.82	3.52	4.40	4.93	5.64	6.34	8.81
24	1.54	2.31	3.07	3.84	4.80	5.38	6.15	6.92	9.61
26	1.67	2.50	3.33	4.16	5.20	5.83	6.66	7.50	10.41
28	1.79	2.69	3.59	4.48	5.61	6.28	7.17	8.07	11.21
30	1.92	2.88	3.84	4.80	6.01	6.73	7.69	8.65	12.01
32	2.05	3.07	4.10	5.12	6.41	7.17	8.20	9.22	12.81

TABLE C
KEYSTONE AND STRAIGHT SLOTS
PERCENT OPEN AREA PER LINEAL FOOT OF PIPE
SLOTS 2″ LONG, SPACED ON 6″ CENTERS
PIPE SIZE — 7 INCHES O.D.

Number of Rows	Slot Width in Thousandths of an Inch								
	40	60	80	100	125	140	160	180	250
6	0.36	0.55	0.73	0.91	1.14	1.27	1.46	1.64	2.27
8	0.49	0.73	0.97	1.21	1.52	1.70	1.94	2.18	3.03
10	0.61	0.91	1.21	1.52	1.89	2.12	2.43	2.73	3.79
12	0.73	1.09	1.46	1.82	2.27	2.55	2.91	3.27	4.55
14	0.85	1.27	1.70	2.12	2.65	2.97	3.40	3.82	5.31

16	0.97	1.46	1.94	2.43	3.03	3.40	3.88	4.37	6.06
18	1.09	1.64	2.18	2.73	3.41	3.82	4.37	4.91	6.82
20	1.21	1.82	2.43	3.03	3.79	4.24	4.85	5.46	7.58
22	1.33	2.00	2.67	3.33	4.17	4.67	5.34	6.00	8.34
24	1.46	2.18	2.91	3.64	4.55	5.09	5.82	6.55	9.09
26	1.58	2.36	3.15	3.94	4.93	5.52	6.31	7.09	9.85
28	1.70	2.55	3.40	4.24	5.31	5.94	6.79	7.64	10.61
30	1.82	2.73	3.64	4.55	5.68	6.37	7.28	8.18	11.37
32	1.94	2.91	3.88	4.85	6.06	6.79	7.76	8.73	12.13

TABLE D — STANDARD PERFORATION PATTERNS

Size of Liner O.D., inches	Slot Width inches	No. Rows	% Open Area/ft.	Liner O.D., inches	Size of Slot Width inches	No. Rows	% Open Area/ft.
4	.040	24	2.54	5	.040	32	2.72
	.060	16	2.54		.060	16	2.04
	.080	12	2.54		.080	16	2.72
	.100	12	3.18		.100	12	2.55
	.120	8	2.54		.120	12	3.06
	.140	8	2.96		.140	8	2.38
	.160	8	3.39		.160	8	2.72
	.180	8	3.81		.180	8	3.06
4 - 1/2	.040	32	3.01	5 - 1/2	.040	32	2.47
	.060	16	2.25		.060	24	2.79
	.080	12	2.25		.080	16	2.47
	.100	12	2.82		.100	12	2.31
	.120	8	2.25		.120	12	2.78
	.140	8	2.63		.140	8	2.16
	.160	8	3.01		.160	8	2.47
	.180	8	3.39		.180	8	2.78
4 - 3/4	.040	32	2.86	5 - 3/4	.040	32	2.36
	.060	16	2.14		.060	24	2.65
	.080	16	2.86		.080	16	2.36
	.100	12	2.68		.100	12	2.21
	.120	12	3.21		.120	12	2.65
	.140	8	2.50		.140	12	3.09
	.160	8	2.86		.160	8	2.36
	.180	8	3.22		.180	8	2.65

TABLE D — STANDARD PERFORATION PATTERNS (con't.)

Size of Liner O.D., inches	Slot Width inches	No. Rows	% Open Area/ft.	Size of Liner O.D., inches	Slot Width inches	No. Rows	% Open Area/ft.
6	.040	32	2.27	6 - 5/8	.120	12	2.30
	.060	24	2.55		.140	12	2.68
	.080	16	2.27		.160	12	3.08
	.100	16	2.83		.180	8	2.30
	.120	12	2.55	7	.040	32	1.94
	.140	12	2.97		.060	32	2.90
	.160	8	2.27		.080	24	2.90
	.180	8	2.55		.100	16	2.42
6 - 5/8	.040	32	2.05		.120	16	2.90
	.060	24	2.30		.140	12	2.54
	.080	24	3.08		.160	12	2.90
	.100	16	2.56		.180	8	2.18

TABLE E

PRE-PACK OR FLOW PACK GRAVEL SIZES

Gravel Size Mesh	Screen Opening — Inches		Gravel Size Mesh	Screen Opening — Inches	
	Passes Through	Stops On		Passes Through	Stops On
10 - 16	.065	.039	5 - 8	.156	.093
8 - 10	.093	.065	3/16	.218	.156
6 - 9	.131	.078	1/4	.279	.223
6 - 8	.131	.093	5/16	.343	.281
20 - 40	**.0328**	**.0165**	**16 - 20**	**.0469**	**.0331**
12 - 18	**.0661**	**.0394**	**18 - 20**	**.0394**	**.0331**

TABLE F

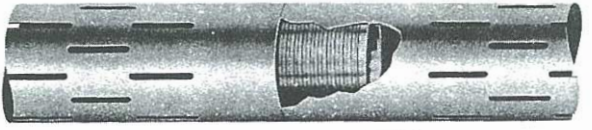
SUGGESTED SCREEN LINER DIMENSIONS

API Pipe Diam. Inner Liner, inches	Outer Diam. of Screen, inches	O.D. of Casing to Run In, inches	API Pipe Diam. Inner Liner, inches	Outer Diam. of Screen, inches	O.D. of Casing to Run In, inches
2 - 3/8	2.88	5	5 - 1/2	6.01	8 - 5/8
2 - 7/8	3.38	5 - 1/2	5 - 3/4	N/A	8 - 5/8
3 - 1/2	4.00	5 - 3/4	6 - 5/8	7.14	9 - 5/8
4	4.50	6 - 5/8	7	7.52	10 - 3/4
4 - 1/2	5.00	7	7 - 5/8	8.15	10 - 3/4
4 - 3/4	N/A	7			
5	5.51	7 - 5/8			

The outer screen can be ordered to any desired diameter to fit special conditions.

FLUSH JOINTS

Flush-type joints are often required in special liner work to permit larger diameter pipe to be used in open hole or run through casing. Absence of couplings also prevents bridging of gravel during flow pack operations. Ventura Modified Acme Flush Joint is a single step thread. It spins fast, is extra strong in tensile load-bearing strength and seals against either external or internal pressure. Actual test data can be made available upon request.



Tubing and Casing Joint Efficiency
Ventura Flush Joint Modified Acme Thread
For the More Popular Sizes

Pipe Size O.D., Inches	Lbs. Per Ft. (Nom.)	Lbs. Per Ft. (Pln. End)	Wall Thick., Inches	I.D. Nom., Inches	% Jt. Eff. Min.
1.9	2.75	2.72	.145	1.610	47.7
2 - 3/8	4.60	4.43	.190	1.994	47.7
2 - 7/8	6.40	6.16	.217	2.441	49.7
3½	9.20	8.81	.254	2.992	53.2
	10.20	9.91	.289	2.922	53.9
4	9.50	9.11	.226	3.548	51.0
	11.00	10.46	.262	3.476	54.1
4½	12.60	12.24	.271	3.958	53.9
	16.6	14.98	.337	3.826	54.0
5 (1)	15.0	14.87	.296	4.408	51.1
	18.0	17.93	.362	4.276	54.2
	21.0	20.67	.423	4.154	56.5
5½ (2)	17.0	16.87	.304	4.892	54.8
	20.0	19.81	.361	4.778	55.1
6 - 5/8	24.0	23.58	.352	5.921	51.0
	28.0	27.65	.417	5.791	54.0
7	26.0	25.66	.362	6.276	54.0

(1) Actual yield point in test of N-80 pipe 256,365 lbs. Computed minimum yield 228,724 lbs.
(2) Actual yield point in test of J-55 pipe 192,700 lbs. Computed minimum yield 176,297 lbs.
(3) All standard sizes are available.

CASING DATA

O.D.	Weight	Nominal I.D.	Drift I.D.	Coupling O.D.
4"	11.60	3.428	3.303	4.484
4 - 1/2"	9.50	4.090	3.965	5.000
	11.60	4.000	3.875	5.000
	13.50	3.920	3.795	5.000
4 - 3/4"	16.00	4.082	3.957	5.364
5"	11.50	4.560	4.435	5.563
	13.00	4.494	4.369	5.563
	15.00	4.408	4.283	5.563
	17.70	4.300	4.175	5.563
	18.00	4.276	4.151	5.563
	21.00	4.154	4.029	5.563
5 - 1/2"	13.00	5.044	4.919	6.050
	14.00	5.012	4.887	6.050
	15.00	4.974	4.849	6.050
	15.50	4.950	4.825	6.050
	17.00	4.892	4.767	6.050
	20.00	4.778	4.653	6.050
	23.00	4.670	4.545	6.050
5 - 3/4"	14.00	5.290	5.165	6.437
	17.00	5.190	5.065	6.437
	19.50	5.090	4.965	6.437
	22.50	4.990	4.865	6.437
6"	15.00	5.524	5.399	6.625
	16.00	5.500	5.375	6.625
	18.00	5.424	5.299	6.625
	20.00	5.352	5.227	6.625
	23.00	5.240	5.115	6.625
6 - 5/8"	17.00	6.135	6.010	7.390
	20.00	6.049	5.924	7.390
	22.00	5.989	5.864	7.390
	24.00	5.921	5.796	7.390
	26.00	5.855	5.730	7.390
	26.80	5.837	5.712	7.390
	28.00	5.791	5.666	7.390
	29.00	5.761	5.636	7.390
	32.00	5.675	5.550	7.390
7"	17.00	6.538	6.413	7.656
	20.00	6.456	6.331	7.656
	22.00	6.398	6.273	7.656
	23.00	6.366	6.241	7.656
	24.00	6.336	6.211	7.656
	26.00	6.276	6.151	7.656
	28.00	6.214	6.089	7.656
	29.00	6.184	6.059	7.656
	30.00	6.154	6.029	7.656
	32.00	6.094	5.969	7.656
	35.00	6.004	5.879	7.656
	38.00	5.920	5.795	7.656
	40.00	5.836	5.711	7.750
7 - 5/8"	20.00	7.125	7.000	8.500
	24.00	7.025	6.900	8.500
	26.40	6.969	6.844	8.500
	29.70	6.875	6.750	8.500
	33.70	6.765	6.640	8.500
	39.00	6.625	6.500	8.500
8 - 5/8"	24.00	8.097	7.972	9.625
	28.00	8.017	7.892	9.625
	32.00	7.921	7.796	9.625
	36.00	7.825	7.700	9.625
	38.00	7.775	7.650	9.625
	40.00	7.725	7.600	9.625
	43.00	7.651	7.526	9.625
	44.00	7.625	7.500	9.625
	49.00	7.511	7.386	9.625
9"	34.00	8.290	8.165	10.000
	38.00	8.196	8.071	10.000
	40.00	8.150	8.025	10.000
	45.00	8.032	7.907	10.000
	55.00	7.812	7.687	10.000
9 - 5/8"	29.30	9.063	8.907	10.625
	32.30	9.001	8.845	10.625
	36.00	8.921	8.765	10.625
	40.00	8.835	8.679	10.625
	43.50	8.755	8.599	10.625
	47.00	8.681	8.525	10.625
	53.50	8.535	8.379	10.625

CASING DATA

O.D.	Weight	Nominal I.D.	Drift I.D.	Coupling O.D.
10"	33.00	9.384	9.228	11.002
10 - 3/4"	32.75	10.192	10.036	11.750
	40.00	10.054	9.898	11.866
	40.50	10.050	9.894	11.750
	45.00	9.960	9.804	11.866
	45.50	9.950	9.794	11.750
	48.00	9.902	9.746	11.866
	51.00	9.850	9.694	11.750
	54.00	9.784	9.628	11.866
	55.50	9.760	9.604	11.750
11 - 3/4"	38.00	11.150	10.994	12.750
	42.00	11.084	10.928	12.750
	47.00	11.000	10.844	12.750
	54.00	10.880	10.724	12.750
	60.00	10.772	10.616	12.750
12"	40.00	11.384	11.228	13.116
13"	40.00	12.438	12.282	14.116
	45.00	12.360	12.204	14.116
	50.00	12.282	12.126	14.116
	54.00	12.220	12.064	14.116
13 - 3/8"	48.00	12.715	12.559	14.375
	54.50	12.615	12.459	14.375
	61.00	12.515	12.359	14.375
	68.00	12.415	12.259	14.375
	72.00	12.347	12.191	14.375
	83.00	12.175	12.019	14.375
	85.00	12.159	12.003	14.375
16"	55.00	15.375	15.187	17.000
	65.00	15.250	15.062	17.000
	75.00	15.125	14.937	17.000
	84.00	15.010	14.822	17.000
18 - 5/8"	78.00	17.855	17.667	19.625
	87.50	17.755	17.567	19.625
	96.50	17.655	17.467	19.625
20"	90.00	19.190	19.002	21.563
	94.00	19.124	18.936	21.000
21½"	92.50	20.710	20.522	22.500
	103.00	20.610	20.422	22.500
	114.00	20.510	20.322	22.500
24½"	100.50	23.750	23.562	25.500
	113.00	23.650	23.462	25.500

DECIMAL EQUIVALENTS OF FRACTIONS OF ONE INCH

		1/64	.015625			33/64	.515625
	1/32		.03125		17/32		.53125
		3/64	.046875			35/64	.546875
1/16			.0625	9/16			.5625
		5/64	.078125			37/64	.578125
	3/32		.09375		19/32		.59375
		7/64	.109375			39/64	.609375
1/8			.125	5/8			.625
		9/64	.140625			41/64	.640625
	5/32		.15625		21/32		.65625
		11/64	.171875			43/64	.671875
3/16			.1875	11/16			.6875
		13/64	.203125			45/64	.703125
	7/32		.21875		23/32		.71875
		15/64	.234375			47/64	.734375
1/4			.25	3/4			.75
		17/64	.265625			49/64	.765625
	9/32		.28125		25/32		.78125
		19/64	.296875			51/64	.796875
5/16			.3125	13/16			.8125
		21/64	.328125			53/64	.828125
	11/32		.34375		27/32		.84375
		23/64	.359375			55/64	.859375
3/8			.375	7/8			.875
		25/64	.390625			57/64	.890625
	13/32		.40625		29/32		.90625
		27/64	.421875			59/64	.921875
7/16			.4375	15/16			.9375
		29/64	.453125			61/64	.953125
	15/32		.46875		31/32		.96875
		31/64	.484375			63/64	.984375
1/2			.5	1			1.

LIST OF SERVICES & EQUIPMENT AVAILABLE
ISO 9002 Registration Pending

All Hazardous Materials are recycled and disposed of according to EPA Regulations

API CERTIFIED 1995

PERFORATING ..... 1" through 18"
- Straight and Undercut Slotting
- Round hole 1/4" through 5/8"

THREADING ..... 2" through 13 3/8"
- Security Flush
- Ventura Flush
- VP2 Step
- 8 Round and 10 V
- 11 1/2 V
- Buttress
- API Rotary Tool Joints
- "W" Series Flush Joint
- ASTM F480 Flush Joint

GENERAL MILL WORK
- Liner Equipment
- Flange and Wellhead Repair Services
- Complete Shop Welding Services
- Drill Collar and Drill Pipe Handling and Repair

WE INSTALL LOW CARBON AND STAINLESS STEEL
- Wirewrap Screen Liners
- 2 3/8" through 9 5/8"

SHOP MACHINERY 24 Hour Availability

4 ..... 12 ½' Hollow Spindle Lathes
1 ..... 9 ¼" Hollow Spindle Lathe
1 ..... 7" Hollow Spindle Lathe
5 ..... Allen Perforating Machines
1 ...40 Spindle Round Hole Perforating Machine
1 ..... #4 Cincinnatti Mill
1 ..... Tool Makers Mill

Valley Perforating Co.
3201 Gulf Street
Bakersfield, CA 93308
(805) 324-4964
FAX (805) 324-0536