The Permeator - A New Tool For Complete Reservoir Control

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THE PERMEATOR (Trademark of Permeator Corporation) is a new field-proven tool for well completion. It is a powerful aid, not only to completion operations, but also to stimulation treatments and to producing operations throughout the life of the well.

The new device constitutes a miniature flow line from the producing formation to the well bore and prevents contact of completion or well fluids with the cement behind the casing.

Advantages of this technique are:

It eliminates explosive perforating, and thereby prevents hole-to-hole communication from fractured cement, and eliminates casing burrs and "junk" in the hole.

It protects the cement bond between casing and formation by confining stimulation pressures and fluids to the formation face.

Perforations are uniform, since all devices are exactly the same size. This means that fluid flow through each tool at a given differential pressure will always be the same. Such flow-pressure relationships are very helpful when the limited-entry technique in fracturing is used.

The mechanism contains machined seats for ball sealers, and allows complete isolation of desired zones during stimulations and workovers. And the smaller seats are designed for balls which do not protrude into the casing, so that tools and packers can be run.

It is ideal for multi-tubingless completions, since it eliminates the possibility of perforating through the opposite strings of casing.

HOW IT WORKS

The device consists of two concentric telescoping steel tubes mounted inside a threaded base assembly. The base assembly screws into a mounting pad welded onto the casing over a hole which has been drilled or cut into the casing (Figure 1).

Each of the steel tubes contains a shear ring that holds it in closed position until a predetermined pressure is applied to the inside of the casing. Each tube contains an "O" ring to prevent leakage. A lock ring insures that once the tohe is extended, it will lock permanently and thus prevent the tubes from retracting.

The tool can be mounted in the desired pattern on any size, weight, grade, or length of casing, as shown in Figure 2. After the mounting pads are in place, skid bars are welded on the casing to act as centralizers. All welds are stress relieved.

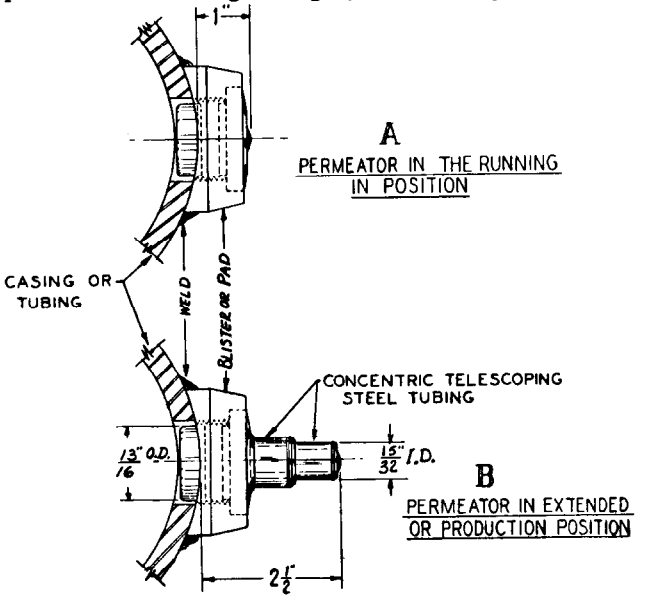
The assembled tool is flush with the internal wall of the casing and extends approximately 1 in. out from the external wall. The exact extension is determined by the size and weight of casing used. The skid bars extend 1 in. from the surface of the casing; thus it protects the mechanism assembly while it is being run into the well.

When the steel tubes have been extended to the open position shown in Figure 1, the standard device extends 2 1/2 in. from the surface of the casing. This means that diameter of the drilled hole must be greater than 2 in., and less than 5 in. greater than the casing size to permit the standard assembly to be used. However, special long-reach tools can be used in holes up to 7 in. larger than casing size.

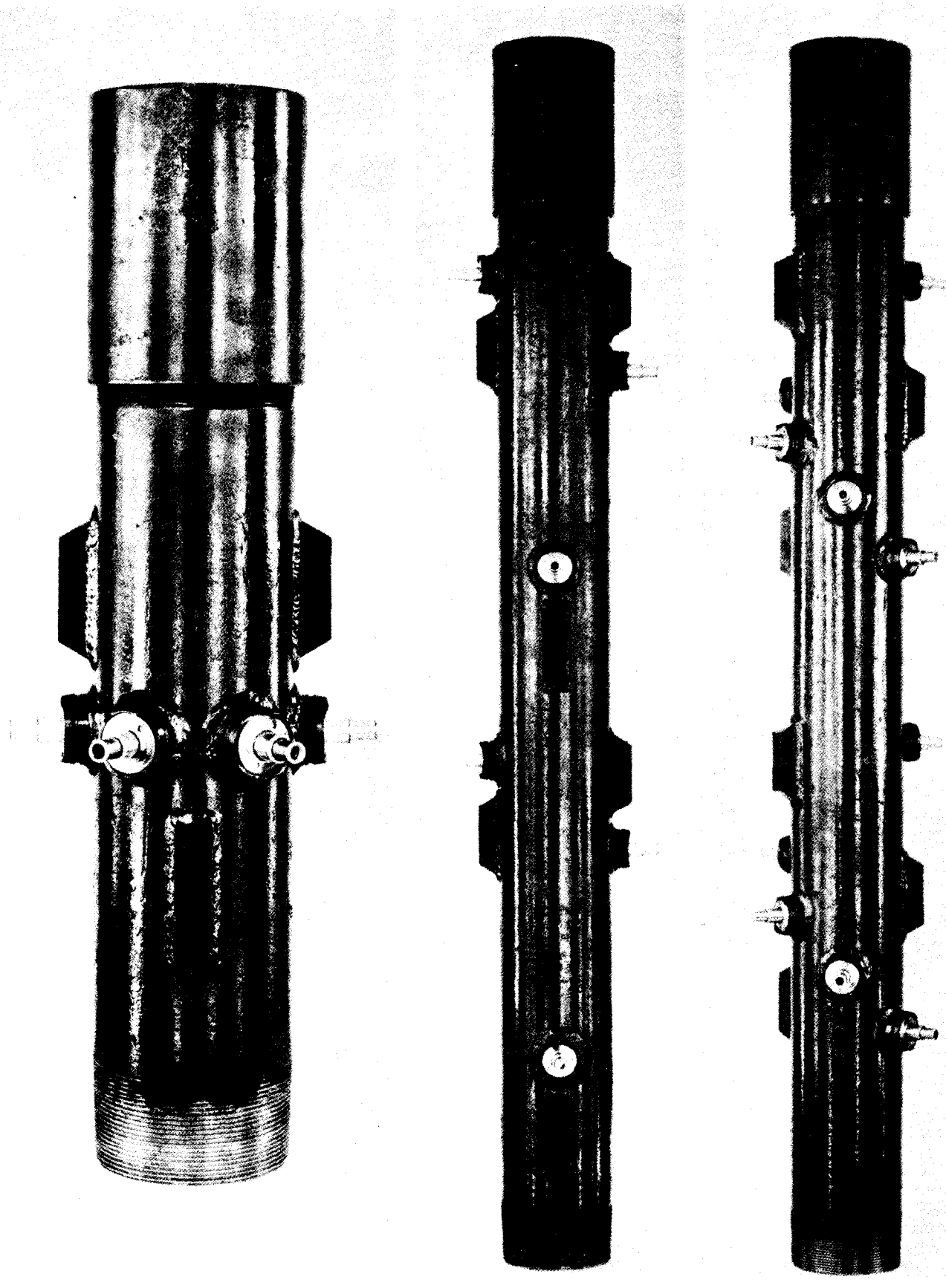
When all the base assemblies have been welded onto a length of casing, the mounting pad are plugged, and the casing is pressure tested. Then the plugs are removed; the mechanisms are installed, and the casing is again tested. Protective covers (Figure 3) are used for protection during shipping.

Operation

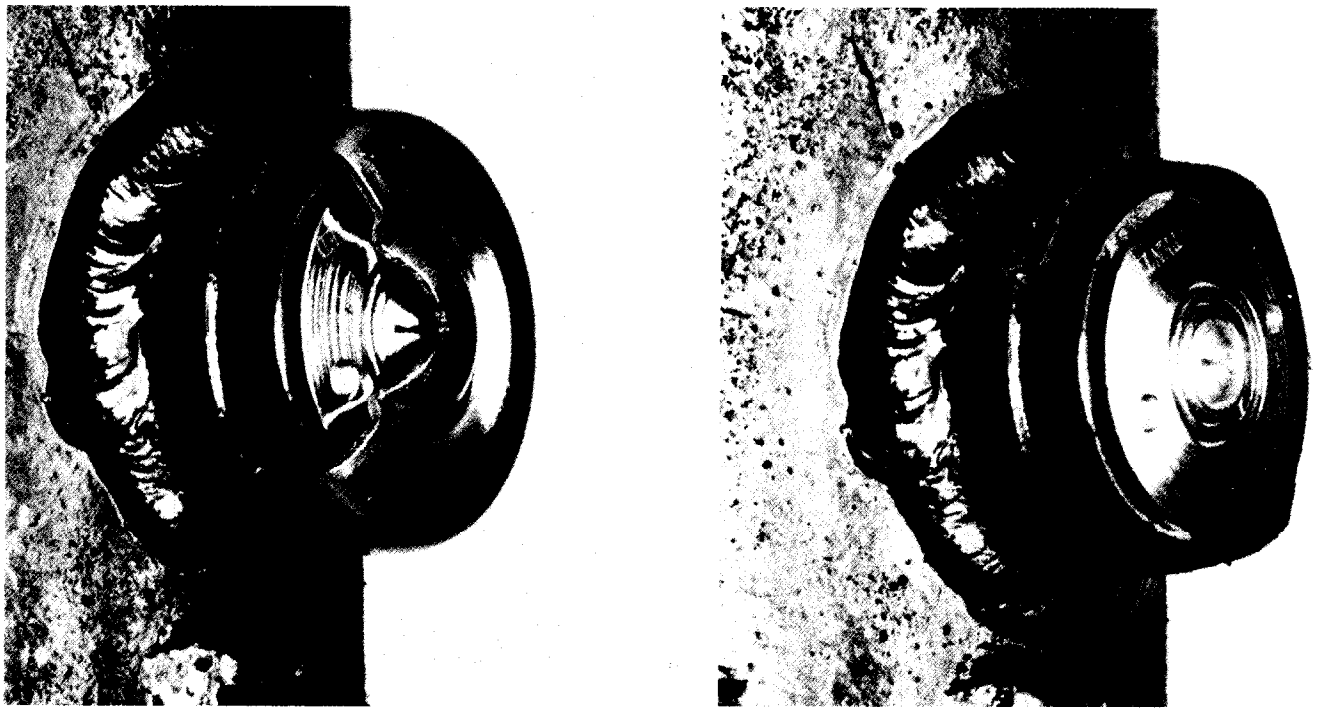
The casing with tools installed is then properly spaced in the casing string by correlating open-hole



SIMPLIFIED CROSS SECTIONS of Permeator casing assembly. Fig. 1.



PERMEATORS ARE VERSATILE, and may be installed on the casing in a number of ways. Note the skid bars just above the Permeators in photo at left.



PROTECTIVE COVER assures that the Permeator assembly will not be damaged in shipment. Photo at right shows Permeator with cover removed. Fig. 3.

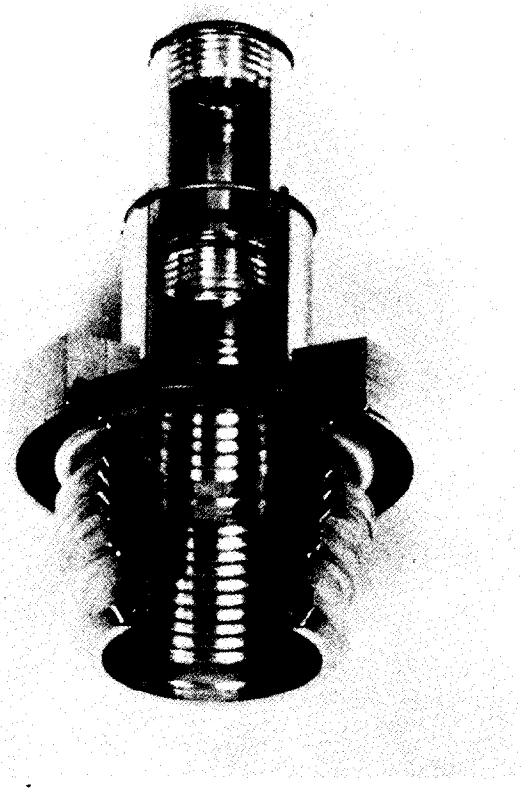
logs with drilling depths. The casing string is run into the well, and the tools are positioned by casing talley, or with a gamma-ray collar log, depending on the accuracy required. Casing is cemented in the conventional manner, with enough special acid solution being injected behind the top cement plug to cover the tools installed on the casing.

When the top cement plug is landed, pressure on the casing is increased by 2000 psi. This pressure shears the magnesium shear rings in each telescoping tube, and the tubes are forced through the unset cement into the formation. While the cement obtains its initial set, the special acid solution dissolves the magnesium plugs. This dissolving action is timed so that the devices are not opened to the formation until after the cement has set.

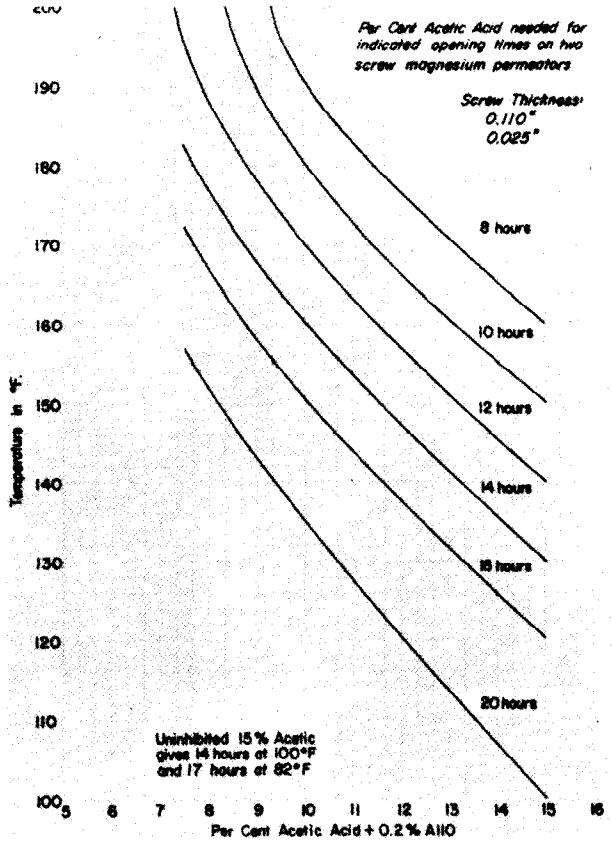
Types

There are 3 types of Permeators, each with either the standard 2 1/2 in. extension or the special 3 1/2 in. extension:

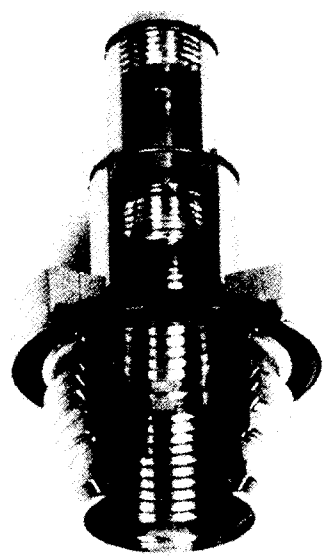
1. Two-screw magnesium, or regular (Figure 4): This model contains two magnesium plugs which are dissolved by acetic acid. Opening time can be controlled by varying the acid concentration, depending on bottom-hole temperature (Figure 5).
2. Two-screw aluminum, or storage (Figure 6): This model contains aluminum plugs which are not affected by acetic acid. It remains unopened until hydrochloric acid is spotted across the section.



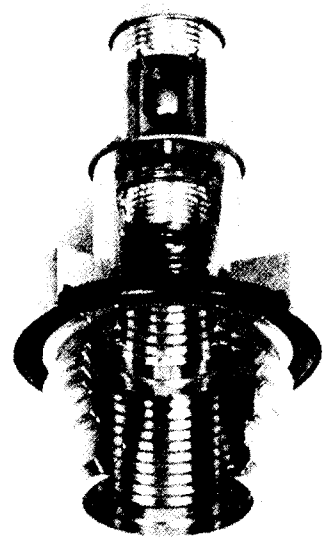
TWO-SCREW MAGNESIUM, or regular Permeator. Fig. 4.



DIFFERENT OPENING TIMES can be obtained at different bottom-hole temperatures by varying acid concentration. Fig. 5.



TWO-SCREW ALUMINUM, or storage Permeator. Fig. 6.



BALL-CHECK Permeator. Fig. 7.

3. Ball-check (Figure 7): This model is constructed with magnesium and zinc plugs, which are opened by acetic acid. Fluid can then flow into the well bore, but the formation fluids are prevented from entering the casing by an aluminum check valve. When the well is ready for production, hydrochloric acid is spotted over the Permeators. The ball-and seat mechanism is then dissolved, creating an unrestricted flow line from formation into the well bore.

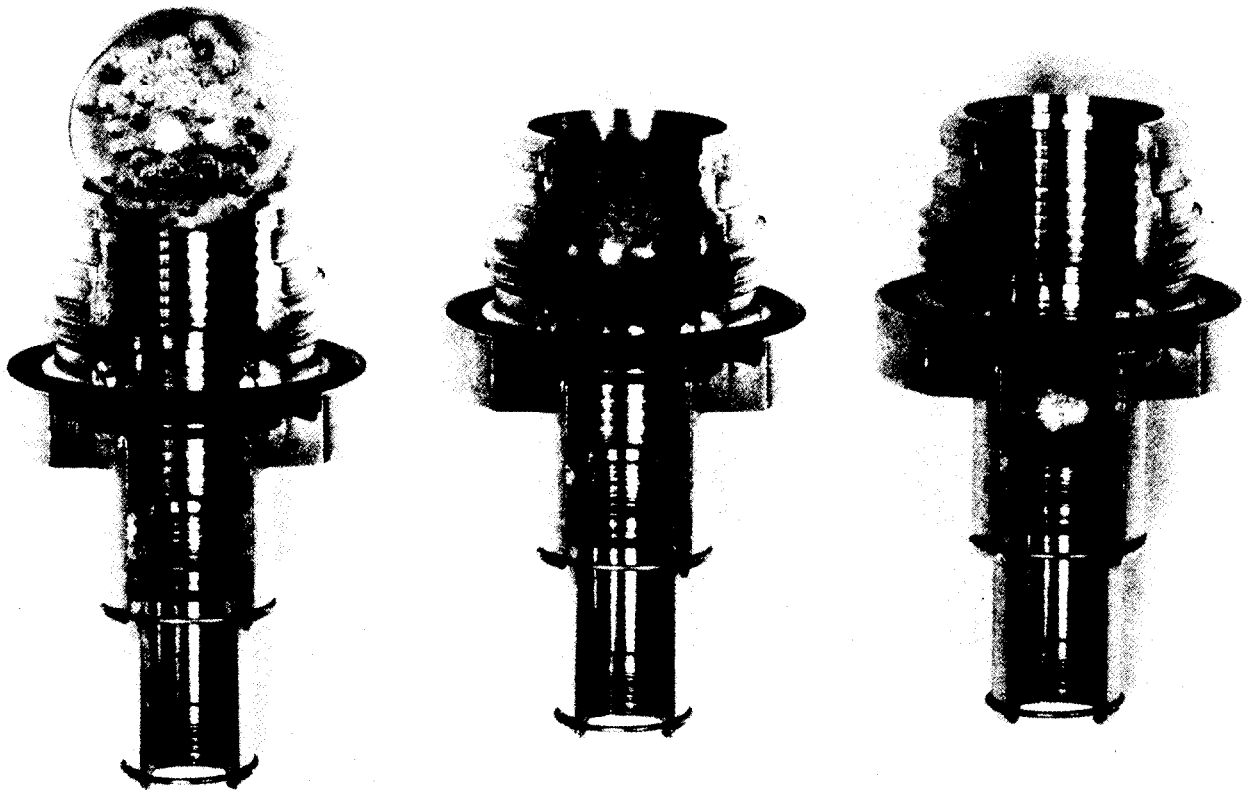
Selective Stimulation

As shown in Figure 8, the device is constructed with 3 machined seats for ball sealers: to take a 1/2 in. ball, another to take a 3/4 in. ball, and the third to take a 1 in. ball. When special non-deforming balls are used, a positive seal results with any 1 of the 3 balls. Seal effectiveness during stimulation treatment is shown in Figure 9. This means that the operator has positive control over the diversion of stimulation fluids, so that the exposed formations may be selectively treated.

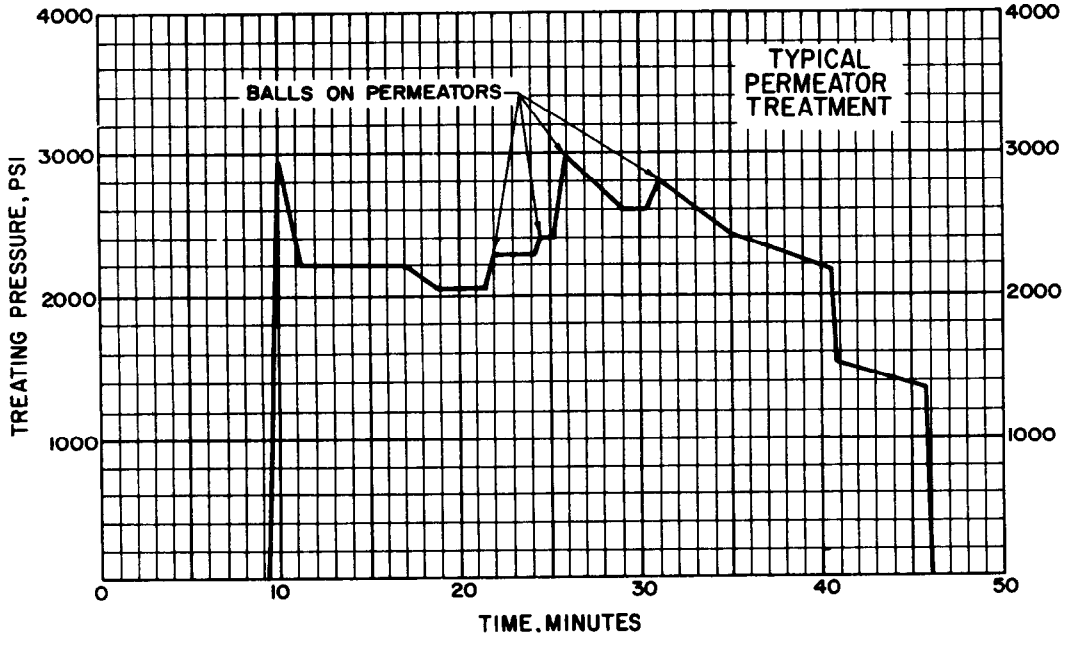
During workover programs, any 1 zone can be isolated, assuring positive direction of workover fluids into any section of the well. The 2 smaller balls seat completely inside the device and give full clearance inside the casing. This allows tools to be run through the perforated section while it is sealed off.

Limited Entry

Many oil companies design their completions using a minimum number of perforations (limited-entry technique). These perforations are spotted throughout the producing intervals so that treating the well with a specified volume of fluid at a specified pressure insures that fluid will be injected into all the perforated sections.

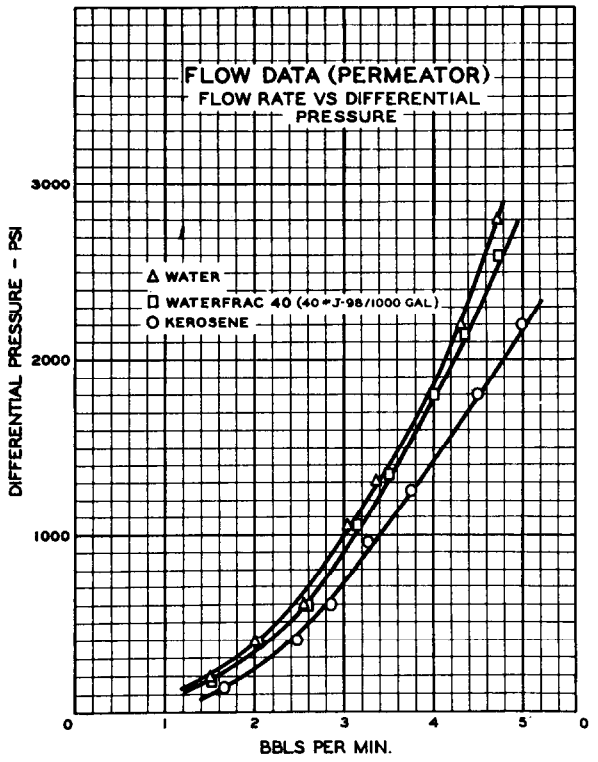


THREE BALL SEATS are machined into each Permeator. Fig. 8.



POSITIVE SEAL is obtained when using special ball sealers with Permeators. Fig. 9.

Since all Permeators are exactly the same size, the number of holes being pumped through at any given time can be determined very accurately from the calibration curve shown in Figure 10.



FLOW CHARACTERISTICS of Permeators with different fluids. Fig. 10.

FIELD RESULTS

The Permeator completion method has been applied to more than 100 wells, and in most cases these wells have produced better than comparable wells in the same field. Some typical case histories are shown in Table 1.

As shown in this table, Well No. 8, completed in Boundry Lake field in Boundry Lake sand at 4455 ft, produced 110 BOPD compared to 50 BOPD for conventional production in the same field. Thirty devices were used in a 72 ft section.

Well No. 15, completed in Guest Canyon field in Canyon sand at 4687 ft, produced 20 BOPH, compared to 4-7 BOPH for conventional production in the field. Eleven devices were used in a limited-entry section.

Six of the 9 oil wells shown in Table 1 showed increases over average production for comparable wells in the same fields.

PRECAUTIONS AND LIMITATIONS

Our technique is not a panacea for all the troubles usually found in completing, stimulating, and producing wells. But it is a powerful tool to help bring about complete reservoir control, if these precautions and limitations are observed:

1. Hole size is critical for application of Permeators. The assembly adds about 2 in. to the diameter of the casing. The fully extended standard device extends 2 1/2 in. from the surface of the casing, and the fully extended long-reach tool extends 3 1/2 in. from the surface. Thus, hole diameter must be at least 2 in. larger, and not over 7 in. larger, than is diameter of the casing.
2. Accurate placement of Permeator casing sections is essential. Careful measurement, or running a radioactive collar log prior to the cement job is necessary to obtain the desired accuracy.
3. If there is caving or washed-out formation conditions, a caliper log is required to establish whether the device can be used.
4. If the casing cannot be run to the desired depth, the hole can be cleaned out and the casing rerun. Or casing may be cemented out of position with the tools in closed position. The well can then be perforated conventionally.

ACKNOWLEDGMENT

We appreciate the encouragement of the management of the Dowell Division of the Dow Chemical Company in the preparation of this paper.

TABLE 1

TYPICAL CASE HISTORIES OF WELLS COMPLETED USING THE PERMEATOR TECHNIQUE

Well No.	Field	Formation	Number of Permeators						
Well No.	Field	Formation	Depth	Number of Permeators	Length of Section (ft)	Casing Size (in)	Type Stimulation	Production	Conventional Production
1	Hermattan	Mississippi	8830	90	45	4-1/2	2500 gal. Acid	80 BOPD	50-100 BOPD
2	Boundry Lake Sand	Boundry Lake	4445	24	8	4-1/2	1500 gal. Acid 35 Balls	Non commercial	
3	East Laprise	Baldonnel	4285	113	80	4-1/2	5000 gal. Acid 150 Balls	2.5 MMCFD	2-3 MMCFD
4	Martin	San Andres	4572	4	Limited Entry	4-1/2		Mechanical Failure	
5	Nig Creek	Baldonnel	4446	108	70	4-1/2	3000 gal. Acid 108 Balls	2.6 MMCFD	2-3 MMCFD
6	Swan Hills	Slavepoint	7826	307	136	4-1/2	5000 gal. Acid	Testing	
7	Nig Creek	Baldonnel	4538	78	80	5-1/2	4250 gal. Acid 78 Balls	6.8 MMCFD	5-7 MMCFD
8	Boundry Lake	Boundry Lake Sand	4455	30	72	4-1/2	5000 gal. Acid	110 BOPD	50 BOPD
9	Swan Hills	Slavepoint	7876	54	31	4-1/2		100 BOPD	60 BOPD
10	Ward Estate	Yates	2610	4	Limited Entry	2-7/8	Frac	Mechanical Failure	
11	Guest Canyon	Canyon Sand	4509	6	Limited Entry	4-1/2	1000 gal. Acid 20,000 gal. Frac	16 BOPH	4-7 BOPH
12	Guest Canyon	Canyon Sand	4658	10	Limited Entry	4-1/2	1000 gal. Acid 20,000 gal. Frac	8 BOPH	4-7 BOPH
13	Guest Canyon	Canyon Sand	4706	8	Limited Entry	4-1/2	1000 gal. Acid 20,000 gal. Frac	18 BOPH	4-7 BOPH
14	Guest Canyon	Canyon Sand	4600	8	Limited Entry	4-1/2	1000 gal. Acid 20,000 gal. Frac	20 BOPH	4-7 BOPH
15	Guest Canyon	Canyon Sand	4687	11	Limited Entry	4-1/2	1000 gal. Acid 20,000 gal. Frac	20 BOPH	4-7 BOPH
16	Bethany	Mooringsport	4000	36	12	3-1/2	60,000 gal. Frac	17 BOPH	15-20 BOPH