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HYDROSTATIC COMPACTING

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HYDROSTATIC COMPACTING*

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Hydrostatic compacting, a fairly new development in the forming of unusual materials, has gained much interest in the past five years, both as a research tool and as a production process. This process is also known as isostatic pressing, which means that the material is subjected to equal pressure from every side and is this in hydrostatic equilibrium, as a body submerged in a liquid at rest. It can be used in forming metals, ceramics or clay, plastics, synthetic rubber, cermets, carbides, high explosives, solid fuels, and other exotic materials.

The process consists of packing the material in a rubber, or plastic-type, bag or mold, removing the air, sealing, and placing in a high pressure autoclave. The pressure fluid can be either water, synthetic, or petroleum-based. Pressure is applied and maintained for a given period of time. The material being compacted is then returned to atmospheric pressure.

Some of the advantages of hydrostatic compacting are that it provides higher density, uniformity of compactness, added strength, purity, and the ability to combine materials, such as glass and copper. The procedure reduces stress concentrations and eliminates soft cores in the compacted material. Exotic shapes and hazardous materials can be compacted with a minimum of personal exposure and with limited scrap.

* This work performed under the auspices of the U.S. Atomic Energy commission.

Hydrostatic compacting is three-dimensional, giving uniform strength in all directions; ordinary hydraulic pressing is two-dimensional, producing variations in structure.

Compacting has been done with pressures as low as 5,000 psi, but most equipment today is designed to operate in a range from 30,000 to 50,000 psi. Laboratory units today are capable of operating up to 200,000 psi. At 50,000 psi operating pressure, units are being built with work space 16 inches in diameter and 60 inches long. At the 200,000 psi range, the work area is around 3-4 inches in diameter and 12 inches long.

The bag or mold holding the material to be compacted must be designed so that the fluid medium will not contaminate the material being compacted. For small units, fingers from a rubber surgical glove have been used, with the end sealed with rubber bands. Containers have been made using Amber-Gooch rubber tubing, the ends being sealed with rubber stoppers and rubber bands. Large containers are formed using either butyl rubber, silicone rubber, or urethane rubber. If the compaction is to be in a cylindrical form, added support is given by using a brass sleeve around the rubber tubing.

After the powdered material has been hand-compacted in the mold, it is subjected to a vacuum to reduce possible porosity due to entrapped air bubbles (see Fig. 1). The charge is then placed in the pressure vessel, the closure cover is sealed in position, and the pumping system is started. A vent valve is provided on the closure cover to permit escape of all air trapped in the closing. This venting is important as it eliminates the hazard of having high pressure gas compressed in the vessel. It also decreases the pumping time necessary to reach the desired pressure.

The pumping system is stopped when pressure reaches the desired point. The time that the pressure is held may vary from a few seconds to

hours depending upon the nature of the material being compacted. It has been found desirable to reduce the pressure in steps, so that the sample is not subjected to shock due to quick pressure release. The vessel is vented to return the press to atmosphere, the closure cover is removed, and the compacted material taken out.

Barricades must be provided for all high pressure work irrespective of whether it is pneumatic or hydraulic. We like to think of them as being noncompressible, but unfortunately in high pressure work most fluids are compressible. We also have the expansion of the equipment to contend with. The closure plug on a 16 inch I.D. vessel at 50,000 psi will have a load on it of over 10 million pounds. All types of barricade construction have been used - from the simplest and most commonly used boiler plate, to reinforced concrete.

In the High Pressure Engineering building at the Lawrence Radiation Laboratory (LRL), all test cells are of the reinforced concrete design. A typical cell is shown in Fig. 2. The cell is 12 feet by 13 feet with a 16-foot ceiling. The walls and ceiling are 12 inches thick. Personnel access to the cell is through a 4-foot-wide, $\frac{1}{2}$ -inch-thick, steel plate door. Pipe sleeves, that can be plugged when not in use, are installed for control gear and instrumentation. The cell is also equipped with an "I" beam and a one-ton chain hoist.

A 50,000 psi and a 150,000 psi compacting system have been in use at LRL for four years in a number of research programs. The vessel for the 50,000 psi compacting system is made of SAE 4340 steel with a tensile strength of 156,500 pounds and a yield strength of 125,000 pounds. It has a 6-inch inside diameter and a 24-inch inside depth. The outside diameter is 15 inches and overall height is 35 inches. A 7-inch, 4 threads per inch,

buttress thread, closure plug is provided at one end. Sealing is by a silicone "O" ring. Hydraulic fluid enters the vessel through a port in the bottom and venting is through a port in the closure plug. The vessel is installed on casters and the total weight is 1,525 pounds. This vessel can be heated to 250°C by means of 24 strip heaters installed on the outside wall of the vessel. Each heater is rated at 1,000 watts, 220 volts, 3-phase. Figure 3 gives an overall view of the 50,000 psi system.

For compacting at 150,000 psi, a composite-type vessel is used. The outer cylinder is AISI-E-4340 forging and is 18 inches in diameter and 32 inches long. The inner cylinder is also E-4340 A.Q. HRA, and is 9.5 inches in diameter and 1.42 feet long. The bore is 3 inches in diameter and 12 inches long. Here again, sealing is by an "O" ring, retaining ring, and packing ring. The closure retainer is of the buttress thread design. This system is shown in Fig. 4.

The pumping system for a 50,000 psi generating unit is a double acting intensifier type pump with a 4-inch-diameter low pressure piston driving two 3/4-inch-diameter high pressure pistons. Figure 5 is a schematic of the hydraulic system for this unit. Some specifications for this hydraulic system are given in Table I.

Hydraulic pumping system for the 150,000 psi generating unit is a single-acting intensifier pump with a 2.5-inch-diameter, low-pressure piston, driving a 5/8-inch-diameter, high-pressure piston. Fluid at 30,000 psi is supplied to the low pressure piston. This 30,000 psi pressure is generated by an air operated piston pump. Composite tubing is used on this system. The inside diameter is 0.063 inch and the outside diameter is 0.750 inch. A hydraulic schematic of this system is shown in Fig. 6.

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Table I. 50,000 psi hydraulic system.

Reservoir:	40 gallons
Pump:	Single fixed displacement, 11 gpm dual van 2,000 psi.
Electric Motor:	15 horsepower, 1,200 rpm, 220/440 volt, 60 cycle, 3-phase, drip proof with special end heel to couple pump.
Safety Valve:	(R ₁) spring loaded, manually adjusted, spills excess oil to reservoir at preset pressure.
Safety Valve:	(R ₂) set to open at 20 psi allows oil to flow through filter until line pressure becomes 20 psi when it then opens and oil returns to reservoir.
Fluid Control- Throttle Valve:	(T ₁ -C) throttle valve controls flow of oil to intensifier, thus regulating pumping speed of intensifier. Minimum flow passed is 0.5 gpm. This valve is pressure compensated, holding a constant pressure drop across (T ₁), thus maintaining constant speed as preset regardless of the load and spilling the excess oil back to reservoir.
Valve:	(A) This valve reverses the stroke of the intensifier pump and is a throttle-center, two-position, four-way oil pilot-operated valve with two choke valves to eliminate surge at cross-over.
Valve:	(B) Solenoid operated pilot valve used to actuate valve (A).

Fig. 1. Rubber mold with pumpdown connector.

GLL-646-1558

Fig. 2. Typical high-pressure cell.

GLB-644-1955

Fig. 3. 50,000 psi compacting system.

GLB-644-1956

Fig. 4. 150,000 psi compacting system.

GLL-646-1559

Fig. 5. Hydraulic diagram of 50,000 psi system.

Fig. 6. Hydraulic diagram of 150,000 psi system.

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