UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC TESTS OF BARCLAD SEALING WASHERS

Report No. Hyd-537

Hydraulics Branch
DIVISION OF RESEARCH

OFFICE OF CHIEF ENGINEER
DENVER, COLORADO

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ABSTRACT

Tests were made to determine the effectiveness of special sealing washers in producing watertight seals around the threads of bolts used through bulkheads and gates subjected to high hydrostatic heads. The washers were composed of high-grade buna "N" rubber enclosed on three sides with Type 302 stainless steel. The rubber portion of the washers was convex on one side and concave on the other. Proper installation required the convex side to be placed facing the high pressure. The washers, when properly squeezed by torquing the bolting system, provided watertight sealing for heads up to at least 623 feet of water, or 270 psi. The washers were used effectively to seal the threaded portion of the bolts on either the wet or the dry side of a flange. Within the limits of the testing, the washers were re-usable. The washers should be equally effective when used on the shanks or under the heads of the bolts.

DESCRIPTORS--*water seals/ *leakage/ *high pressures/ low pressures/ bolts/

IDENTIFIERS--washers/

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HYDRAULIC TESTS OF BARCLAD SEALING WASHERS

PURPOSE

Studies were made to determine the effectiveness of Barclad sealing washers for providing watertight seals when used under the nuts on the threaded portion of bolts situated "in the wet" where high differential heads occur.

CONCLUSIONS

1. Leakage resulted at approximately 200 feet of head when the nuts on the 5/8-inch bolts were torqued with 70 foot-pounds.

2. The washers provided watertight sealing against heads of at least 623 feet of water or 270 pounds per square inch (psi) when the nuts were torqued to 82 to 85 foot-pounds.

3. The washers could be used on either the wet side or dry side of the bolted assembly with equal effectiveness (Figure 3).

4. The washers were re-usable within the limits of the study.

5. The washers should be equally or more effective when used on the bolt shanks or under the boltheads. This condition was not tested.

INTRODUCTION

For the unwatering of a pressure conduit or tunnel, and during inspections or maintenance operations, leakage around bolts on gate seal clamps or other bolted surfaces subjected to high-pressure differentials is undesirable.

The procedure used heretofore for preparing boltholes for pressure sealing required drilling, counterboring, and countersinking (Figure 1A). A rubber "O" ring was used under the bolthead or nut to complete the seal when torque was applied to the nut. Leakage often resulted around the "O" ring making a more effective means of sealing desirable.

Two washers of a type developed by the L. J. Barwood Manufacturing Company, Inc., Everett, Massachusetts, were supplied to the Mechanical Branch, and thence given to the laboratory for testing (Figure 2). The washers were composed of high-grade buna "N" rubber enclosed on three sides with Type 302 stainless steel. The rubber portion of the washers was convex on one side and concave on the other (Figure 1B). The operating principle required placing the convex side toward the high pressure so that the pressure would force the rubber tightly against the bolt shank or threads to add to the seal tightness obtained by squeezing the seal when torquing the nuts to the bolts. Use of the washers has the advantage of eliminating the need for the countersinking operation in the preparation of boltholes for gate seal clamps, and offers the promise of fully watertight seals.

EQUIPMENT

The equipment used for the study consisted of a high head pump, a 3/4-inch-thick blind flange with two 11/16-inch-diameter holes near the center, two 5/8 - 11NC, brass, hex-head bolts with nuts, and two Barclad sealing washers (Figures 2 and 3).

TEST PROCEDURE

One bolt was installed with the bolthead on the water side (high-pressure side) of the flange and the nut and washer on the dry side. The second bolt was placed with the head on the dry or low-pressure side of the flange and the nut and washer on the water side (Figure 3). Both washers were installed under the nuts and around the threaded area of the bolts with the convex side toward the high pressure. The threaded area of the bolts was the most difficult position to seal and was the test location requested by the Mechanical Branch. The nuts were torqued to 70 foot-pounds for the first tests, and the flange was bolted to the downstream side of the Venturi meter in the high-head test facility.

After bleeding the air from the lines, the pumping head was increased in 20-foot increments. At a head of 200 feet of water (approximately 87 psi), leakage amounting to an occasional drip was noted around both bolts. Increasing the head to 623 feet (approximately 270 psi) had very little effect on the magnitude of the leakage.

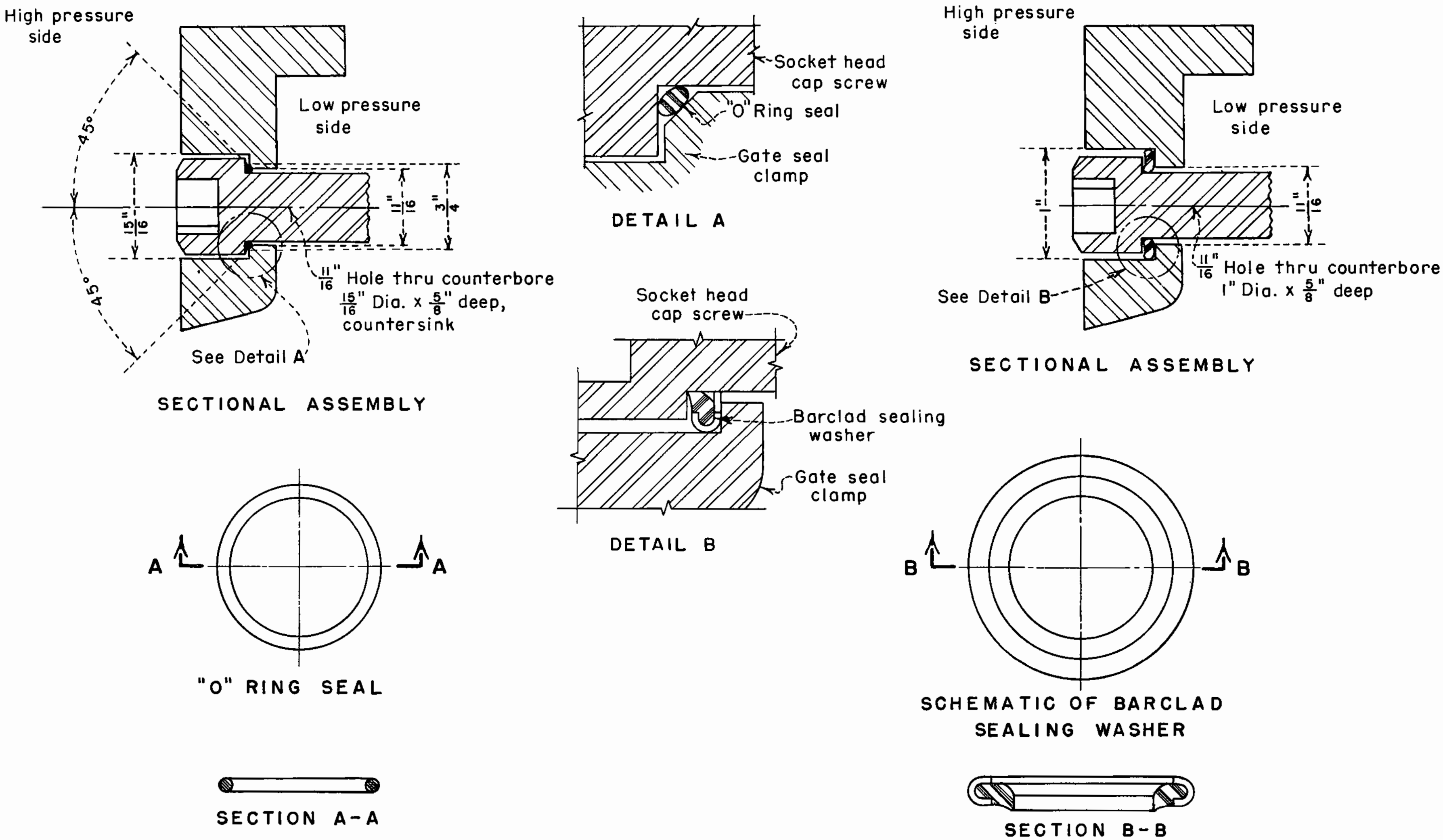
The pump was then shut off, the flange removed, and the parts disassembled and inspected. No visible damage was noted on any of the components.

The bolts and washers were again attached to the flange in the manner above, and the nuts retorqued to 82 to 85 foot-pounds. The flange was bolted to the test facility, and the head increased in 20-foot increments to approximately 623 feet or 270 psi (Figure 3). No leakage occurred.

Prolonged operation of the high-head pump at or near the shutoff head would have resulted in excessive heating and damage to the facility. Therefore, the tests were of short duration; however, the test pressures were more than double the 125 psi requirement placed on the seals.

Within the limits of the test program, the seals were re-usable. No visible damage to the seals was noted other than thread groove prints on the rubber portion after the heavy torquing and high pressure had been applied (Figure 2A).

The excellent performance of the washers when used on the threaded portions of the bolts makes it reasonable to assume that they would be equally or more effective when used on the shanks of the bolts or under the heads, as in Figure 1B. No tests were made under the latter conditions.



A. SEAL CLAMP WITH "O" RING SEAL

B. SEAL CLAMP WITH BARCLAD SEALING WASHER

BARCLAD SEALING WASHERS

TYPICAL SEAL CLAMP ASSEMBLIES WITH "O" RINGS AND SEALING WASHERS

FIGURE 1
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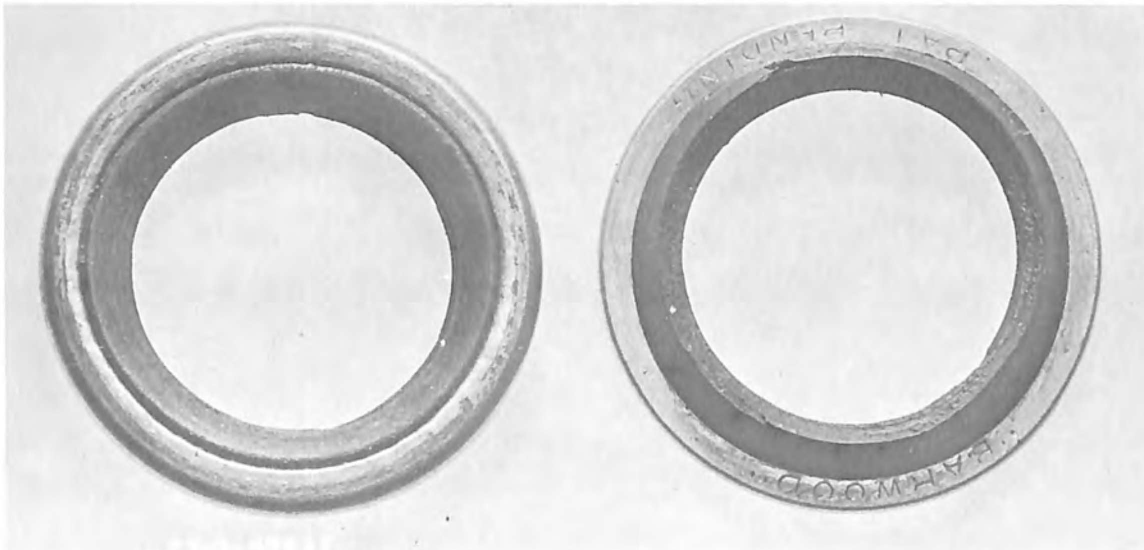
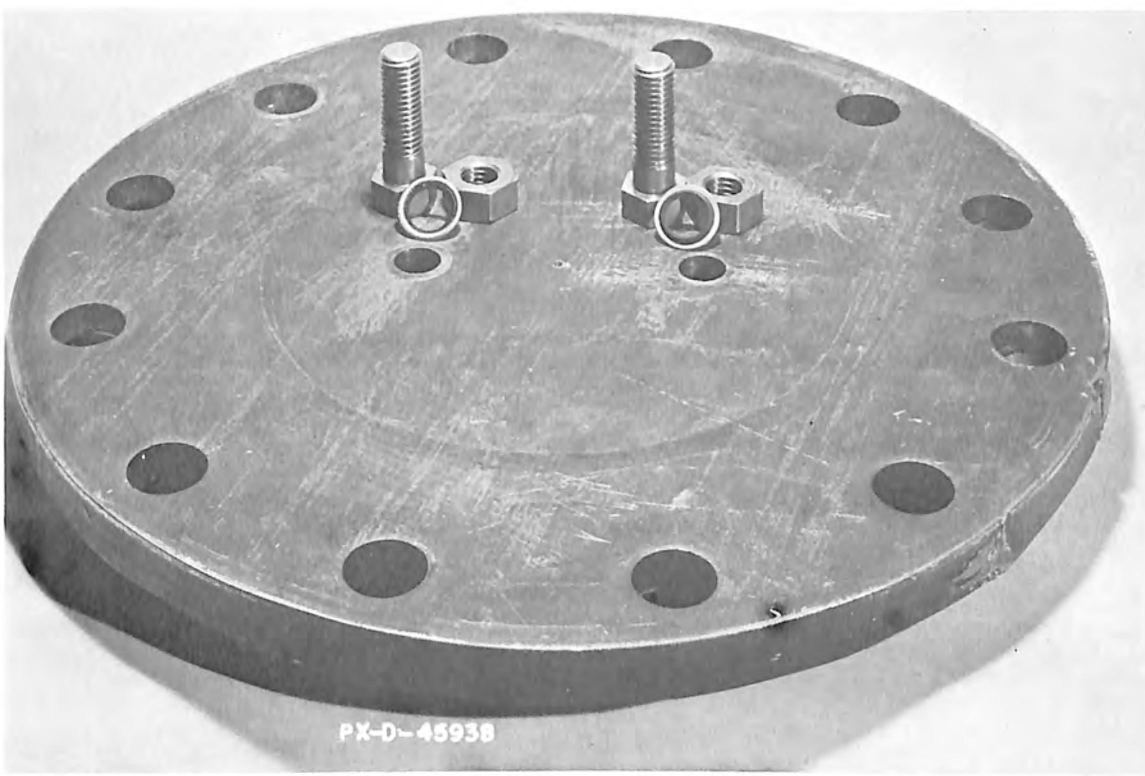


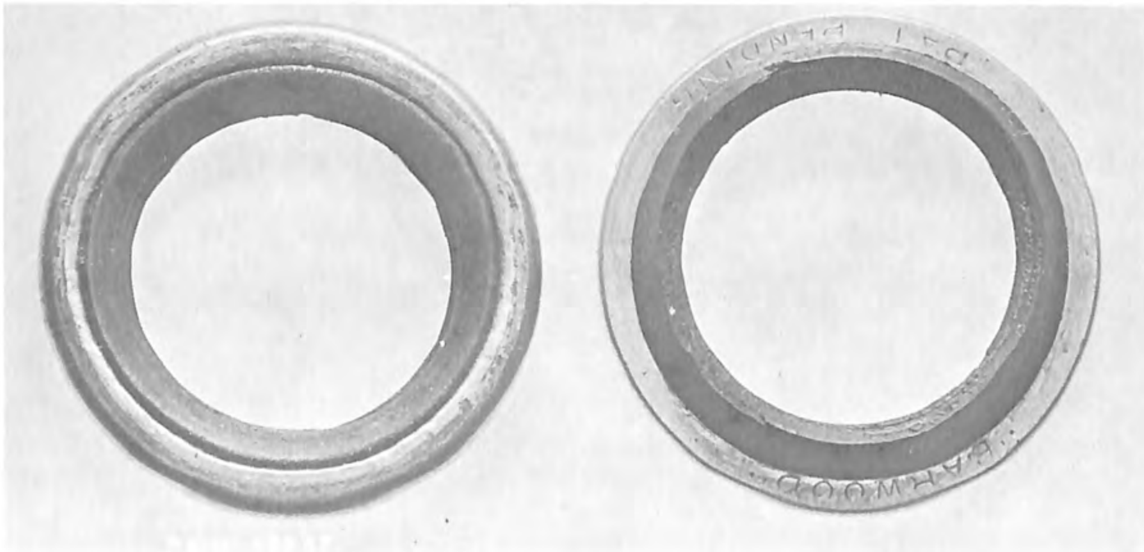
A. Top and bottom of sealing washers after use. Shown approximately 2.5 times actual size after completion of testing.



B. Flange with 11/16" drilled holes, 5/8"-11NC bolts, nuts, and sealing washers.

BARCLAD SEALING WASHERS

Washers with bolts and test flange



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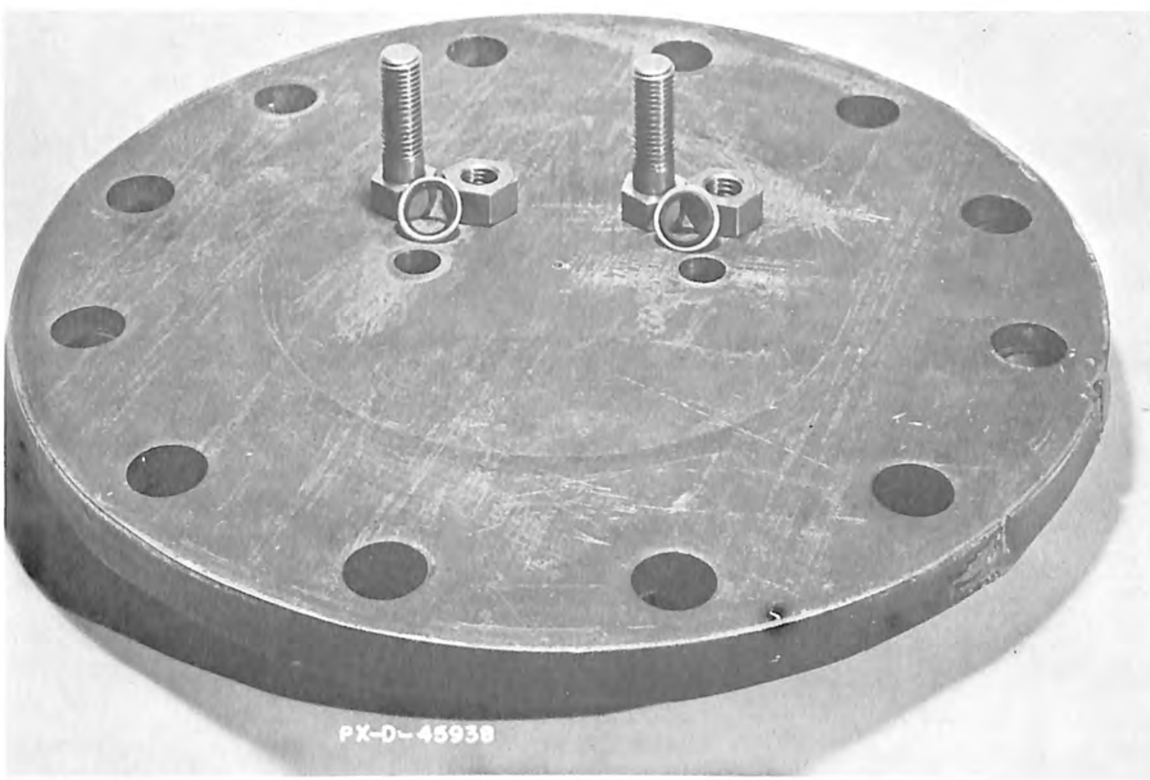

B. Flange with 11/16" drilled holes, 5/8"-11NC bolts, nuts, and sealing washers.

BARCLAD SEALING WASHERS

Washers with bolts and test flange

A. Flange assembly bolted to high head pump installation. Head of 623 feet of water was applied to system. Note that one bolt is placed with the head on the pressure side of the flange while the other is placed with the threaded end and the nut on the pressure side.

BARCLAD SEALING WASHERS

Flange and bolt assembly during tests

CONVERSION FACTORS--BRITISH TO METRIC UNITS OF MEASUREMENT

The following conversion factors adopted by the Bureau of Reclamation are those published by the American Society for Testing and Materials (ASTM Metric Practice Guide, January 1964) except that additional factors (*) commonly used in the Bureau have been added. Further discussion of definitions of quantities and units is given on pages 10-11 of the ASTM Metric Practice Guide.

The metric units and conversion factors adopted by the ASTM are based on the "International System of Units" (designated SI for Systeme International d'Unites), fixed by the International Committee for Weights and Measures; this system is also known as the Giorgi or MKSA (meter-kilogram (mass)-second-ampere) system. This system has been adopted by the International Organization for Standardization in ISO Recommendation R-31.

The metric technical unit of force is the kilogram-force; this is the force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 9.80665 m/sec/sec, the standard acceleration of free fall toward the earth's center for sea level at 45 deg latitude. The metric unit of force in SI units is the newton (N), which is defined as that force which, when applied to a body having a mass of 1 kg, gives it an acceleration of 1 m/sec/sec. These units must be distinguished from the (inconstant) local weight of a body having a mass of 1 kg; that is, the weight of a body is that force with which a body is attracted to the earth and is equal to the mass of a body multiplied by the acceleration due to gravity. However, because it is general practice to use "pound" rather than the technically correct term "pound-force," the term "kilogram" (or derived mass unit) has been used in this guide instead of "kilogram-force" in expressing the conversion factors for forces. The newton unit of force will find increasing use, and is essential in SI units.

Table 1

QUANTITIES AND UNITS OF SPACE

Multiply	By	To obtain
	LENGTH	
Mil	25.4 (exactly)	Micron
Inches	25.4 (exactly)	Millimeters
	2.54 (exactly)*	Centimeters
Feet	30.48 (exactly)	Centimeters
	0.3048 (exactly)*	Meters
	0.0003048 (exactly)*	Kilometers
Yards	0.9144 (exactly)	Meters
Miles (statute)	1,609.344 (exactly)*	Meters
	1.609344 (exactly)	Kilometers
	AREA	
Square inches	6.4516 (exactly)	Square centimeters
Square feet	929.03 (exactly)*	Square centimeters
	0.092903 (exactly)	Square meters
Square yards	0.836127	Square meters
Acres	0.40469*	Hectares
	4,046.9*	Square meters
	0.0040469*	Square kilometers
Square miles	2.58999	Square kilometers
	VOLUME	
Cubic inches	16.3871	Cubic centimeters
Cubic feet	0.0283168	Cubic meters
Cubic yards	0.764555	Cubic meters
	CAPACITY	
Fluid ounces (U.S.)	29.5737	Cubic centimeters
	29.5729	Milliliters
Liquid pints (U.S.)	0.473179	Cubic decimeters
	0.473166	Liters
Quarts (U.S.)	9,463.58	Cubic centimeters
	0.946358	Liters
Gallons (U.S.)	3,785.43*	Cubic centimeters
	3.78543	Cubic decimeters
	3.78533	Liters
	0.00378543*	Cubic meters
Gallons (U.K.)	4.54609	Cubic decimeters
	4.54596	Liters
Cubic feet	28.3160	Liters
Cubic yards	764.55*	Liters
Acre-feet	1,233.5*	Cubic meters
	1,233,500*	Liters

Table II

QUANTITIES AND UNITS OF MECHANICS

Multiply	By	To obtain
MASS		
Grains (1/7,000 lb)	64.79891 (exactly)	Milligrams
Troy ounces (480 grains)	31.1035	Grams
Ounces (avdp)	28.3495	Grams
Pounds (avdp)	0.45359237 (exactly)	Kilograms
Short tons (2,000 lb)	907.185	Kilograms
	0.907185	Metric tons
Long tons (2,240 lb)	1,016.05	Kilograms
FORCE/AREA		
Pounds per square inch	0.070307	Kilograms per square centimeter
	0.689476	Newtons per square centimeter
Pounds per square foot	4.88243	Kilograms per square meter
	47.8803	Newtons per square meter
MASS/VOLUME (DENSITY)		
Ounces per cubic inch	1.72999	Grams per cubic centimeter
Pounds per cubic foot	16.0185	Kilograms per cubic meter
	0.0160185	Grams per cubic centimeter
Tons (long) per cubic yard	1.32894	Grams per cubic centimeter
MASS/CAPACITY		
Ounces per gallon (U.S.)	7.4893	Grams per liter
Ounces per gallon (U.K.)	6.2362	Grams per liter
Pounds per gallon (U.S.)	119.829	Grams per liter
Pounds per gallon (U.K.)	99.779	Grams per liter
BENDING MOMENT OR TORQUE		
Inch-pounds	0.011521	Meter-kilograms
	1.12985×10^{6}	Centimeter-dynes
Foot-pounds	0.138255	Meter-kilograms
	1.35582×10^{7}	Centimeter-dynes
Foot-pounds per inch	5.4431	Centimeter-kilograms per centimeter
Ounce-inches	72.008	Gram-centimeters
VELOCITY		
Feet per second	30.48 (exactly)	Centimeters per second
	0.3048 (exactly)*	Meters per second
Feet per year	0.965873×10^{-6}	Centimeters per second
Miles per hour	1.609344 (exactly)	Kilometers per hour
	0.44704 (exactly)	Meters per second
ACCELERATION*		
Feet per second^2	0.3048*	Meters per second^2
FLOW		
Cubic feet per second (second-feet)	0.028317*	Cubic meters per second
Cubic feet per minute	0.4719	Liters per second
Gallons (U.S.) per minute	0.06309	Liters per second

Multiply	By	To obtain
FORCE*		
Pounds	0.453592*	Kilograms
	4.4482*	Newtons
	4.4482×10^{-5}*	Dynes
WORK AND ENERGY*		
British thermal units (Btu)	0.252*	Kilogram calories
	1,055.06	Joules
Btu per pound	2.326 (exactly)	Joules per gram
Foot-pounds	1.35582*	Joules
POWER		
Horsepower	745.700	Watts
Btu per hour	0.293071	Watts
Foot-pounds per second	1.35582	Watts
HEAT TRANSFER		
Btu in./hr ft^2 deg F (k, thermal conductivity)	1.442	Milliwatts/cm deg C
	0.1240	Kg cal/hr m deg C
Btu ft/hr ft^2 deg F	1.4880*	Kg cal m/hr m^2 deg C
Btu/hr ft^2 deg F (C, thermal conductance)	0.568	Milliwatts/cm^2 deg C
	4.882	Kg cal/hr m^2 deg C
Deg F hr ft^2/Btu (R, thermal resistance)	1.761	Deg C cm^2/milliwatt
Btu/lb deg F (c, heat capacity)	4.1868	J/g deg C
Btu/lb deg F	1.000*	Cal/gram deg C
Ft^2/hr (thermal diffusivity)	0.2581	Cm^2/sec
	0.09290*	M^2/hr
WATER VAPOR TRANSMISSION		
Grains/hr ft^2 (water vapor transmission)	16.7	Grams/24 hr m^2
Perms (permeance)	0.659	Metric perms
Perm-inches (permeability)	1.67	Metric perm-centimeters

Table III

OTHER QUANTITIES AND UNITS

Multiply	By	To obtain
Cubic feet per square foot per day (seepage)	304.8*	Liters per square meter per day
Pound-seconds per square foot (viscosity)	4.8824*	Kilogram second per square meter
Square feet per second (viscosity)	0.02903* (exactly)	Square meters per second
Fahrenheit degrees (change)*	5/9 exactly	Celsius or Kelvin degrees (change)*
Volts per mil	0.03937	Kilovolts per millimeter
Lumens per square foot (foot-candles)	10.764	Lumens per square meter
Ohm-circular mils per foot	0.001662	Ohm-square millimeters per meter
Millicuries per cubic foot	35.3147*	Millicuries per cubic meter
Milliamps per square foot	10.7639*	Milliamps per square meter
Gallons per square yard	4.527219*	Liters per square meter
Pounds per inch	0.17858*	Kilograms per centimeter

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ABSTRACT

Tests were made to determine the effectiveness of special sealing washers in producing watertight seals around the threads of bolts used through bulkheads and gates subjected to high hydrostatic heads. The washers were composed of high-grade buna "N" rubber enclosed on three sides with Type 302 stainless steel. The rubber portion of the washers was convex on one side and concave on the other. Proper installation required the convex side to be placed facing the high pressure. The washers, when properly squeezed by torquing the bolting system, provided watertight sealing for heads up to at least 623 feet of water, or 270 psi. The washers were used effectively to seal the threaded portion of the bolts on either the wet or the dry side of a flange. Within the limits of the testing, the washers were re-usable. The washers should be equally effective when used on the shanks or under the heads of the bolts.

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