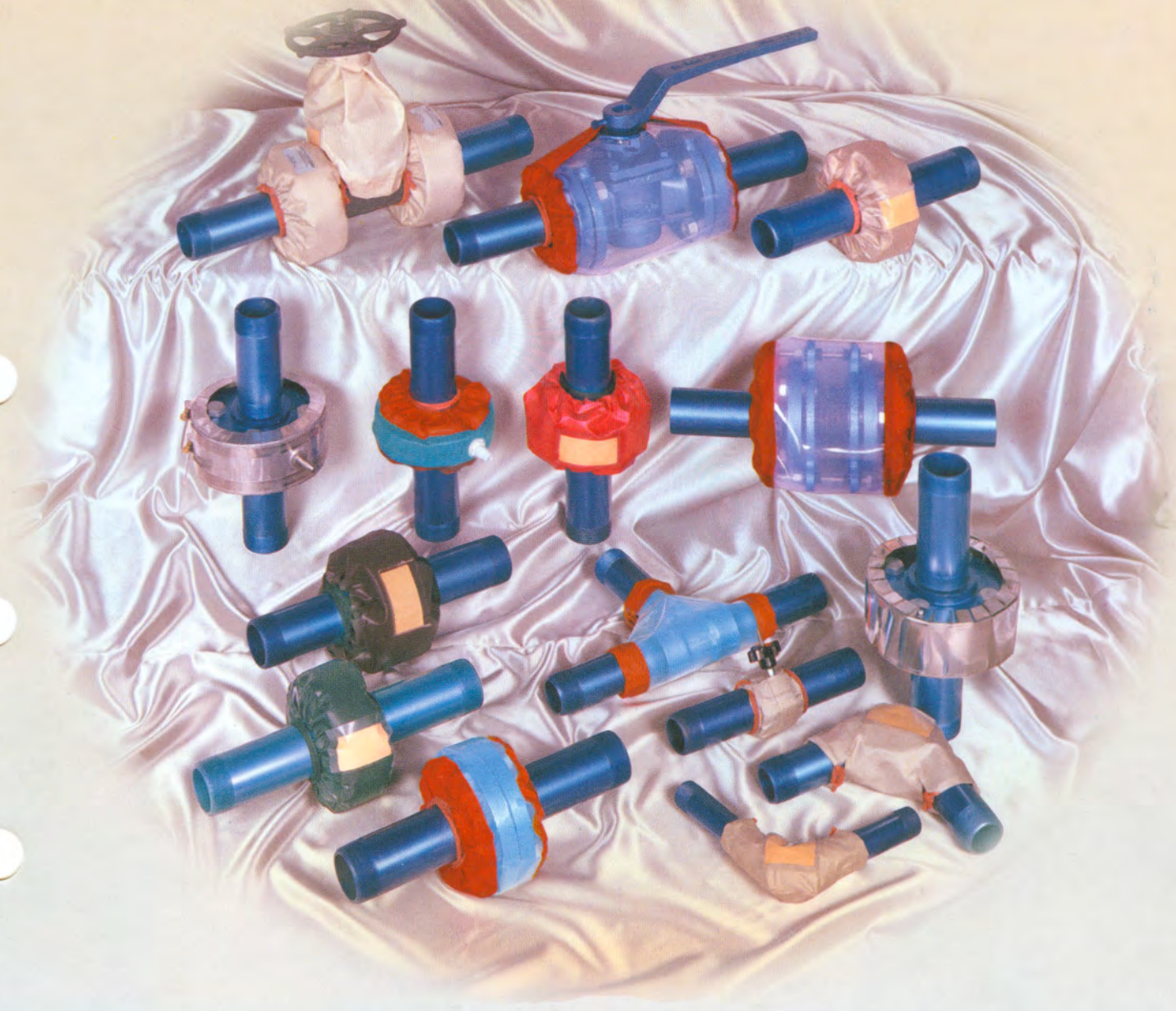
SAFETY SHIELD MANUAL



RAMCO®

"ASSURING SAFETY REQUIRES QUALITY BEYOND DOUBT... ANYTHING ELSE INVOLVES RISK"

SYSTEM CERTIFICATION ISO 9001:2000 SGS

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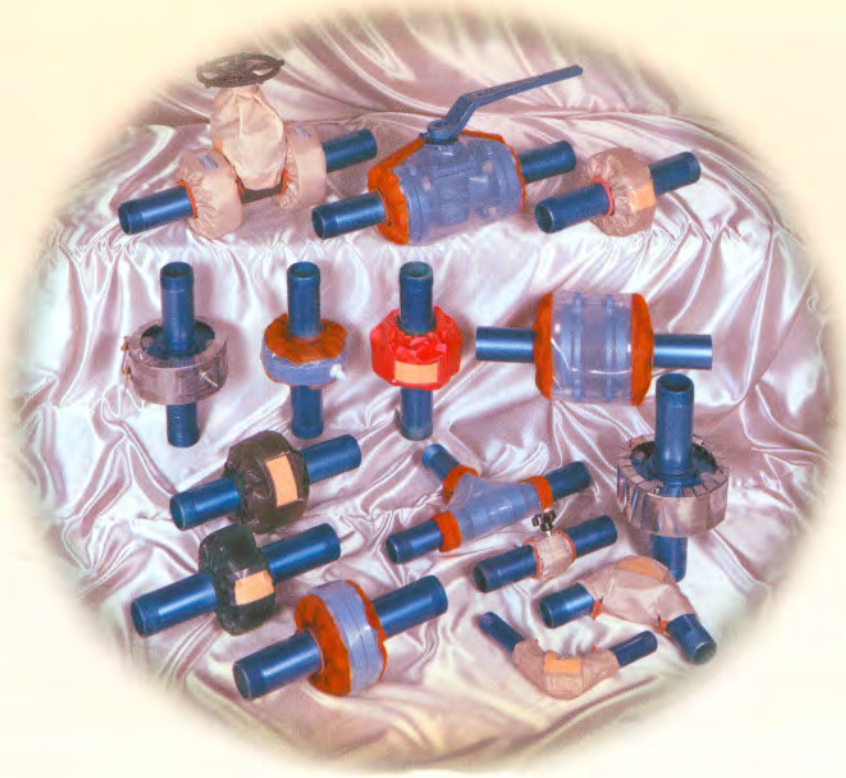

Information in this manual is presented to assist engineers, designers and maintenance personnel in the selection of the safety shield that is effective for a particular application. This edition is an update of earlier manuals and incorporates the latest available information.

RAMCO® Manufacturing Company, Inc. believes that the information herein is accurate based on data available at the time of publication and that the products mentioned are suitable for the applications recommended. This information is based on test data, field experience and information from material suppliers and is believed to be accurate. However, varying conditions may exist in any installation. These may include atmosphere, temperature, pressure, exposure to additional or unidentified chemicals, chemical concentrations and various other parameters. Since these factors are not within its control and cannot be anticipated by RAMCO® Manufacturing Company, Inc., no expressed or implied warranty or guarantee applies as to general or specific results by reason of the use of RAMCO® Safety Shields or information contained in this manual. It is the Buyer's responsibility to determine the appropriateness of RAMCO® Safety Shields for specific end uses. RAMCO® Manufacturing Company, Inc. reserves the right to change product specifications without prior notice.

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Through the years, Man has struggled for personal safety. He learned to interpose an impregnable barrier between himself and danger. The device Man invented and has used consistently for this purpose is the shield. It has served virtually every age in numerous forms.

Man continues to face danger. One such formidable danger is hazardous, toxic chemicals. Wherever corrosive chemical fluids are being transported through piping, the potential for devastating sprayouts that can cause serious injuries, even fatalities, and extensive equipment damage exist. Safety shields installed over piping connections effectively mitigate the effects of these mishaps. This is a specialized application of the age-old concept of the shield.

The following are registered trademarks of RAMCO® Manufacturing Company, Inc.:

RAMCO® Spra-Gard®

RAMCO® Econo-Gard®

RAMCO® Drain-Gard®

RAMCO® Expando-Gard®

RAMCO® Lined Drain-Gard®

RAMCO® PVC "See-Thru" Econo-Gard®

RAMCO® PPL (Vue) Spra-Gard®

RAMCO® PPL (Vue) Drain-Gard®

RAMCO® Valve-Gard®

RAMCO® Vue-Gard®

RAMCO® Vue-Drain-Gard®

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THE RAMCO® *SAFETY SHIELD MANUAL*

NEW TWELFTH EDITION

Revised and Expanded November 2005

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Quality Management System

RAMCO® Manufacturing Company, Inc. has been assessed and certified as meeting the requirements of ISO 9001:2000. This certification is an assurance to our customers that RAMCO® Safety Shields are manufactured in accordance with the strict quality standards prescribed by the International Organization for Standardization.

Customer focus drives our business and quality system and we continuously seek to ensure that customer requirements are precisely determined and are met with the aim of enhancing customer satisfaction.

Management and employees are committed to continuous improvement in quality and growth by incorporating the following principles in our daily business activities:

- *Meet all customer needs and expectations with our products;*
- *Maintain on-time deliveries;*
- *Utilize the highest quality in raw materials;*
- *Seek to incorporate new technologies in our manufacturing; and*
- *Cross train our employees in more than one job function.*

The Quality Management System implemented by RAMCO® is maintained and continually improved through internal quality auditing, corrective and preventive actions, management reviews and written procedures.

The Quality System is an interrelated process system that can be measured, monitored and analyzed. The system is aligned with corporate strategy and directed by corporate management. Also, management establishes quality objectives and criteria, reviews progress against objectives and criteria, plans and implements improvements, when necessary, and communicates directions and results.

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SECTION

1

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SAFETY SHIELDS

HISTORY

In 1958, RAMCO® Manufacturing Company, Inc. was approached by a New Jersey chemical manufacturer to develop a cost-effective safety device for the control of sprayouts from pipe flanges. While using a make-shift wrap-around steel guard that attached to pipe joints with wire, this company wanted a standardized product that could be manufactured in quantity. RAMCO® considered this challenge and the RAMCO® Metal Safety Shield evolved.

In 1961, the new shield found another application. The U.S.S. Constellation, while docked at the Brooklyn Navy Yard, experienced severe pressure leakage in lubrication lines in its engine room. Because of the injuries and fatalities suffered by the crew, the Navy ordered piping throughout its fleet to be safeguarded against possible recurrence. The Metal Safety Shield made by RAMCO® was tested and specified for this application.

Thus, the first generation of RAMCO® Safety Shields, made of galvanized steel, was used for steam and oil lines and cryogenic service. A similar model in stainless steel was fabricated, shortly thereafter, for highly corrosive chemicals and high temperature applications. Not only is RAMCO® the leading producer of steel shields, but it also has created shields in several thermoplastic materials, each serving specialized uses.

Since the development of the first commercial safety shield by RAMCO®, there has been worldwide acceptance of the capability of a safety shield to prevent injury and damage in the event of a chemical sprayout. And accordingly, their effectiveness has been demonstrated in thousands of installations in industrial plants, governmental services and on naval and commercial vessels.

WHY SAFETY SHIELDS?

With the growing awareness of the importance of safety in the environment, RAMCO® Safety Shields are a natural fit in processes involving hazardous or toxic chemicals. Not only do they provide safety features, but they also permit cost reduction. Shields contribute to worker health and safety by minimizing absenteeism due to accidents caused by contact with leaking chemicals and contain costs because there is no need to train replacement workers. Also, because they prevent sprayouts from harming personnel, shields contribute indirectly to maintaining stable health insurance rates and containing workmen's compensation claims.

HOW SAFETY SHIELDS PROTECT

Safety shields prevent sprayouts by interposing an impregnable barrier between the chemical flowing through the piping system and the external environment.

To provide this protection, safety shields must be produced from special materials that are unaffected by chemicals and can tolerate exposure to various temperatures and pressures. In the event of a leak, the escaping fluid is controlled within the shield, and the pressure is dissipated, allowing the leaking chemical to drip harmlessly to the ground.

RAMCO® manufactures an assortment of safety shields to accommodate the hundreds of liquid chemicals that are used in processing industries at varying temperatures and pressures. By selecting the appropriate shield for a specific application, virtually all situations can be safeguarded.

The RAMCO® Safety Shields that are discussed in this manual are suitable exclusively for liquid chemicals, both hazardous and corrosive, as well as water and steam. Since these shields have not been designed for

use with gases or solids and do not resist radiation, they should not be considered for these applications.

To select the proper safety shield, it is necessary to be familiar with the physical properties of the special materials from which RAMCO® Safety Shields are fabricated and to correlate this information with the chemical, temperature and pressure ratings within the piping system.

It must be emphasized that a safety shield is not designed to stop leaks. ***Its purpose is to indicate, contain and deflect temporarily the escaping fluid and, thereby, prevent a sprayout.*** When shields have been installed, workers can approach a leaking pipe joint safely, shut off the system and make the necessary repairs.

SAFETY SHIELD CHARACTERISTICS

Assuring Safety Requires Quality Beyond Doubt...
anything else involves risk.

RAMCO® Safety Shields deliver the safety and dependability that current technology can provide. Each newly developed safety shield is subjected to laboratory testing. Only when we at RAMCO® are satisfied that we have developed a quality product, do we subject it to field testing. When it successfully passes this hurdle, the shield is put into production, and rigid quality control assures no deviation from the standard.

When considering the specification or purchase of safety shields, the characteristics that should be explored include:

- *Mullen Burst Strength*
- *Tensile Strength*
- *Adequate Hem*
- *Adequate Heat Resistance*
- *Chemical Compatibility*
- *Resistance to Ultra-Violet Light*
- *Adequate Tie-Down Cord*

MULLEN BURST STRENGTH

The safety shield must provide assurance that it will not break or explode when subjected to the pressure in the pipe line should a leak occur. To have an adequate safety margin, the Mullen Burst Strength of the shield must be equal to or greater than two times the psi (pounds per square inch) of pressure in the line.

TENSILE STRENGTH

The ability to maintain integrity of shape, regardless of the pressure within the line, is particularly important for a safety shield. Should the shield stretch or give way at the side, a lateral sprayout could occur. This can be just as devastating as a frontal rupture of the shield.

ADEQUATE HEM

Prevention of a sprayout is not assured just because a flange is covered by a safety shield. Unless the sides of the flange are also protected adequately by the shield, a leaking chemical could redirect its course and escape over the side, resulting in a lateral sprayout. To prevent this, the shield must have sufficient width. When installed, the shield should not only cover the bolts but extend beyond them down to the outside diameter of the pipe.

ADEQUATE HEAT RESISTANCE

The ability to withstand the temperature within a pipe line is critical. While thermoplastics demonstrate stability and are not susceptible to chemical reaction, some cannot withstand elevated temperatures. They deteriorate and melt at relatively low heat levels. A safety shield should not be installed on a

pipe line that is hotter than the temperature capacity of the shield.

CHEMICAL COMPATIBILITY

Regardless how hazardous or toxic the chemical within the piping system, the material from which the shield has been manufactured must demonstrate chemical resistance. In this respect, chemical concentration is also an important factor, and suitability of a particular shield may vary depending on these conditions.

RESISTANCE TO ULTRA-VIOLET (UV) LIGHT

Some thermoplastics used in the manufacture of safety shields are vulnerable to degradation with exposure to UV rays. To resist this degradation, these thermoplastics are specially treated with a UV inhibitor.

TIE CORD

The tie-down cords are the means for maintaining the proper position of the safety shield over the pipe connection. Characteristics of the cord material must include sufficient heat and pressure tolerance, UV resistance and compatibility with the chemicals within the system. Also, of extreme importance, the cord must be capable of maintaining a knot securely and ***must not support a flame.***

BE ASSURED

RAMCO® Safety Shields have been designed and manufactured with full appreciation of these essential characteristics. The assurance of preventing the consequences of a hazardous sprayout by the use of appropriate, effective safety shields must be the deciding factor in the purchase of these products.

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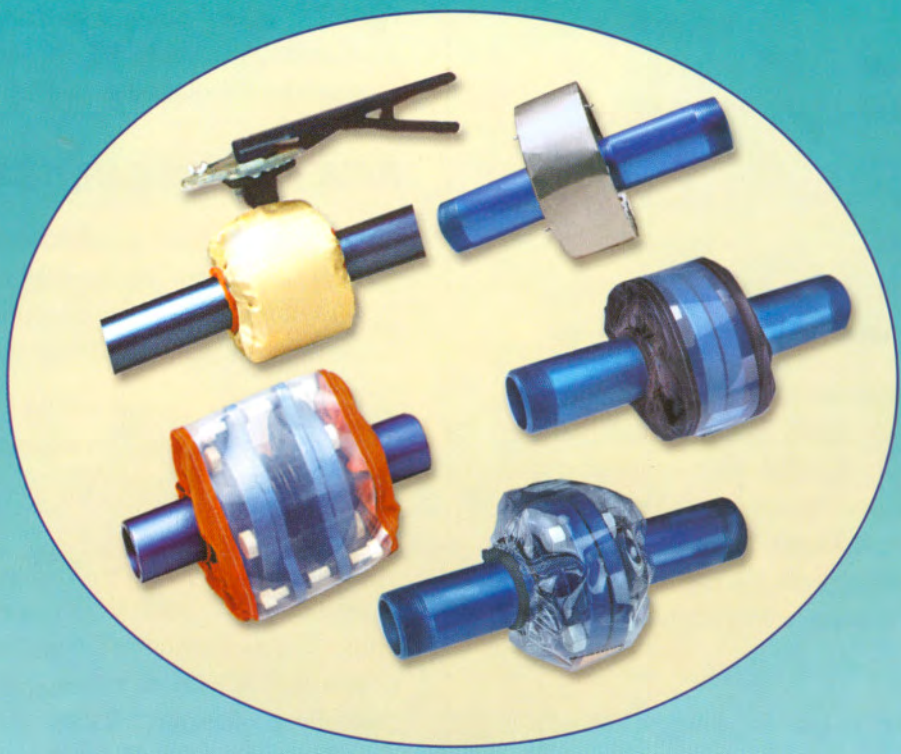

SECTION 2

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TYPES OF RAMCO® SAFETY SHIELDS

RAMCO® Safety Shields are manufactured for all pipe connections such as:

- Flanges
- Valves of all kinds
- Expansion joints
- Flow meters
- Hose couplings
- Heat exchangers
- Pressure vessels
- Customized connections
- Couplings
- Unions
- Elbows
- Tees
- Clamps
- Pumps
- Instruments
- Tube Fittings

Safety shields for flanges are most frequently specified, followed by shields for valves. From the standpoint of safety, all pipe joints are critical, since a sprayout can occur at any connection. However, the likelihood of a sprayout is greatest from flanges because their use outnumbers all other connections. Should a leak become uncontrolled, the consequences can be devastating, regardless of origin.

RAMCO® Safety Shields can be divided into three groups:

- **Spra-Gard® Shields**
- **Econo-Gard® Shields**
- **Metal Safety Shields**

Each group, in turn, contains shields that are manufactured from different materials — a total of eight are currently available. Each type can be fabricated in any size to accommodate the pipe system. While this selection is sufficient to handle virtually all applications, special safety shields can be customized on request.

One major difference among the wide variety of RAMCO® Safety Shields is ***temperature resistance.*** Up to 140°F (60°C) Econo-Gard® Shields are recommended, whereas TFE Spra-Gard® Shields resist temperatures up to 450°F (232°C). Beyond this, Metal Shields are required, demonstrating heat resistance as high as 2650°F (1454°C). Although there are situations in which higher temperatures occur, RAMCO® Safety Shields are not suitable for these environments.

RAMCO® Safety Shields are available in all piping standards (ANSI, DIN, BS, JIS, etc.) and can be customized for special sizes and configurations.

RAMCO® SPRA-GARD® SAFETY SHIELDS

RAMCO® Spra-Gard® Shields, the work horse of safety shields, are most frequently specified because of their wide range of physical characteristics. They are fabricated in three proprietary thermoplastic textiles:

- ***Teflon**** (tetrafluoroethylene or TFE coated fiberglass)
- ***Polypropylene*** (PPL)
- ***ECTFE***

The two woven cloths — TFE and PPL —are developed exclusively for RAMCO® according to specifications. These fabrics are produced to a patented design and a "porosity concept" that has been very carefully engineered. Rather than using impenetrable fabrics, Spra-Gard® Shields are made of slightly porous textiles — too slight to permit a sprayout but sufficient to allow fluid to seep through to the indicating patch in the event of a leak.

ECTFE, a fluoropolymer clear film, is the material that forms the wide center band of the Spra-Gard® "See-Thru" Shields. This non-flammable film withstands temperatures up to 300°F (150°C) and has very high tensile strength. It also demonstrates excellent chemical resistance.

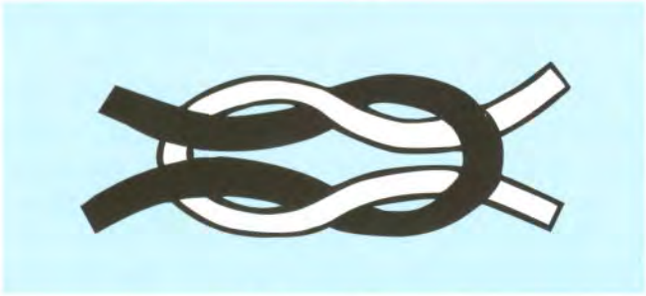
Another common feature of Spra-Gard® Shields is the sensitive pH patch or indicator that is incorporated in each safety shield. Should the slightest amount of leaking fluid come in contact with the patch, the patch undergoes color change immediately signaling trouble in the line. Yellow/orange in color, the indicator turns brilliant red with an acid leak and

*Trademark of E. I. Du Pont De Nemours and Company

bright green with an alkali leak. While the affected patch can no longer be used, it can be removed and replaced with another patch after the shield has been neutralized. The shield is then ready for reuse.

Spra-Gard® Safety Shields have an overlap design. The shields wrap around the pipe connections completely to prevent a lateral sprayout. During installation, they are held in place by means of a velcro fastener. No tools are required, and a single installer can secure a shield over a flange or valve in less than a minute.

Each shield has a pair of tie-down cords. After it has been positioned over the joint and held firmly by its velcro fastener, the cords are drawn tightly around the pipe and secured with a square knot. Use of a square knot is essential, since pressure exerted against a square knot will tighten, ensuring that the shield will maintain its position over the pipe connection.



▲ *Square Knot*

All Spra-Gard® Shields have been subjected to ultraviolet (UV) testing and have performed without degradation for approximately 500 hours.

Material is considered acceptable if it withstands approximately 200 hours of exposure without degradation. This is equivalent to approximately four to five years of outdoor exposure in the tropics and even longer in a temperate zone.

Thus, Spra-Gard® Shields are inhibited against ultraviolet rays and can be installed both indoors and outdoors.

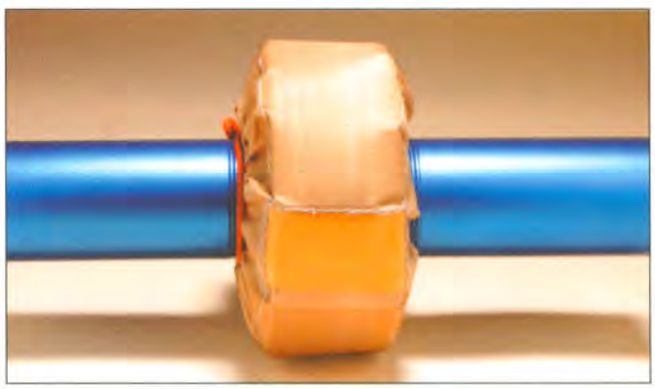
Other critical features of RAMCO® Spra-Gard® Safety Shields are their ability to resist ignition and flame propagation.

Because each Spra-Gard® Safety Shield is produced from a different thermoplastic cloth, parameters for pressure and temperature tolerance and chemical resistance vary.

TFE-SPRA GARD® SAFETY SHIELDS

The unique properties of TFE Spra-Gard® Shields contribute to their high performance. They demonstrate resistance to temperatures up to 450° F (232° C) and pressures up to 1650 psi (114 bar) and are inert to a wide spectrum of commercial chemicals. These shields also show outstanding protection against corrosion.

Because of these physical characteristics, TFE Spra-Gard® Shields are recommended in the chemical, pharmaceutical, electronic, pulp/paper, food processing industries, as well as other vital manufacturing applications in which corrosive chemicals at high temperatures are frequently used.



▲ *RAMCO® TFE Spra-Gard® Shield*

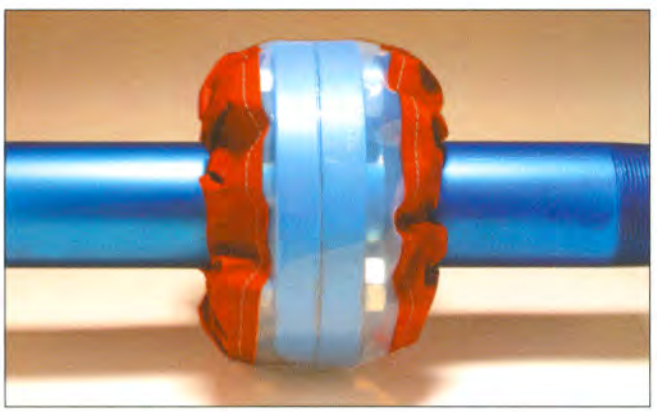
For lines carrying sulfuric acid, the TFE Spra-Gard® Shield is most frequently specified. It can resist this acid at any concentration, including fuming oleum. Only this RAMCO® Shield can be used in this fashion.

VUE-GARD® SAFETY SHIELDS

Another Spra-Gard® product is the innovative "See-Thru" shield that permits easy identification and inspection of all pipe joints, including flanges, valves, threaded connections and expansion joints.

Constructed of TFE coated fiberglass that is burnt orange in color with a wide center band of clear film (ECTFE), the Vue-Gard® Safety Shield permits visual inspection of pipe joints by personnel so leaks can be detected rapidly.

This unique viewing shield withstands temperatures up to 300°F (150°C) and pressures to 1000 psi (69 bar). It demonstrates a broad spectrum of chemical resistance, especially to most corrosive chemicals and organic solvents.



▲ *RAMCO® Vue-Gard® Flange Shield*

Similar in construction to the other Spra-Gard® Shields, the Vue-Gard®'s overlap design completely encompasses a flange connection down to the outside diameter of the pipe; thus, containing both frontal and lateral sprayouts in systems carrying hazardous or toxic chemicals, even under high pressure conditions.

Because of its novel characteristics, this "See-Thru" shield demonstrates a wide scope of applications in the chemical processing industries. In addition to chemical and pharmaceutical uses, this shield is appropriate in refineries as well as pulp and paper operations.

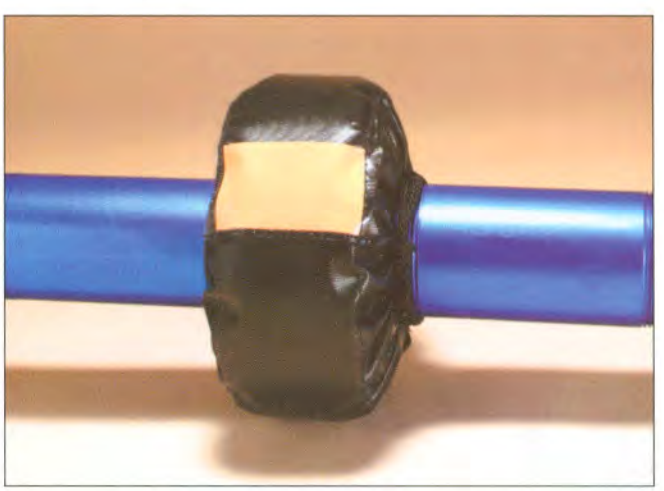
An ideal application of the Vue-Gard® Safety Shield is its custom fabrication for use with sight flow indicators. The clear design of the shield allows easy visualization of the sight window and sight window retainers, as well as the pipe connections.

Judged as a major contribution toward more efficient, effective plant operations in the chemical processing industries, the RAMCO® Vue-Gard® Safety Shield was honored with an award by CHEMICAL PROCESSING in Maintenance/Safety.

▲ *RAMCO® Vue-Gard® Flow Indicator Shield*

PPL SPRA GARD® SAFETY SHIELDS

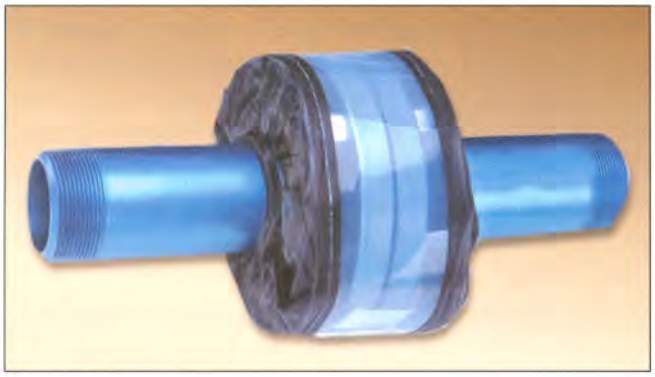
This shield was developed by RAMCO® for a very specific application. Unlike the TFE Spra-Gard® Shield that contains fiberglass, the PPL shield can be used to protect against hydrofluoric acid, a highly virulent chemical that is used to etch glass and is also employed in petroleum cracking operations. Recognizing that the PPL Spra-Gard® Shield provided the first practical safeguard against this hazardous acid, RAMCO® received the John C. Vaaler Award in 1978.



▲ *RAMCO® PPL Spra-Gard® Shield*

While the PPL Spra-Gard® Shield was initially "application specific", the most valuable property of PPL is versatility. This thermoplastic cloth demonstrates temperature and pressure resistance up to 225° F (107°C) and 1100 psi (76 bar), respectively; its chemical tolerance is greatly affected by concentration. For example, at sulfuric acid concentrations of 30% or less, PPL Spra-Gard® Shields are recommended up to line temperatures of 200° F (93° C). However, with 93% or 98% concentrations its use is limited to systems with ambient temperatures.

PPL (VUE) SPRA GARD® SAFETY SHIELDS



▲ *RAMCO® PPL (Vue) Spra-Gard® Shield*

This "See Thru" shield combines the high quality of the RAMCO® PPL Spra-Gard® Shield with the added benefit of clear ECTFE. It is fabricated according to the specifications of all RAMCO® wrap-around shields. Thus, this shield safeguards against both frontal and lateral sprayouts. Its uniqueness, as with the RAMCO® Vue-Gard® Shield, permits easily visual inspection of all pipe connections The PPL (Vue) Spra-Gard® Shield withstands temperatures up to 225° F (107° C) and pressures to 1000 psi (69 bar).

RAMCO® ECONO-GARD® SAFETY SHIELDS

Because of the apparent need for an economical but dependable safety shield, RAMCO® developed the Econo-Gard® Shield. Great attention has been paid to its design to ensure that its economic features have not been achieved at the expense of safety. The modest price of this shield is possible because its fabrication utilizes non-labor intensive heat sealing methods.

Econo-Gard® Safety Shields are available in two thermoplastic materials:

- polyethylene (PE)
- polyvinyl chloride (PVC) (white, red and clear)

While each of the Econo-Gard® Shields has slightly different characteristics, depending on the materials from which they are fabricated, both are manufactured with the same design and feature identical configurations.

The conditions under which Econo-Gard® Shields may be used are limited. They are suitable for temperatures up to 140° F (60° C) and in the presence of certain chemicals, such as concentrated acids, only at lower temperatures. However, they have wide applications, particularly in conditions with ambient temperatures and pressures of 300 psi (21 bar) or lower.

▲ *RAMCO® PVC Red Econo-Gard® Shield*

Similar to Spra-Gard® Shields, Econo-Gard® Shields also wrap-around. Produced from special thermoplastic materials according to RAMCO® specifications, these shields are a three-ply lamination with an inner core of non-woven spun cloth interfaced between two sheets of either PE or PVC. Consequently, a sprayout is prevented by six layers. Four layers, consisting of PE or PVC film, are chemically resistant; the remaining two of non-woven spun cloth provide tensile and burst strength.

Indicating pH patches to signal leaks are also incorporated in Econo-Gard® Safety Shields. Several weep holes behind the patch allow a slight flow of chemical to the indicator which then undergoes color change, alerting plant personnel to the presence of a leak.

The clear PVC Econo-Gard® Shields have the same high quality characteristics of the Econo-Gard® Shields with the added benefit of a "See–Thru" feature, permitting easy visual inspection of pipe joint – flanges, valves and threaded connections. Because of the "See - Thru" feature of this shield, an indicating pH patch is not needed.

▲ *RAMCO® PVC Clear Econo-Gard® Shield*

Subjected to UV testing, Econo-Gard® Shields withstood approximately 430 hours of testing, and at that time demonstrated slight blistering. This period is equivalent to approximately eight to nine years of outdoor exposure in a temperate climate. Consequently, both PE and PVC Econo-Gard® Shields may be installed either indoors or outdoors.

Econo-Gard® Safety Shields are appropriate for installation in chemical processing industries in which less hazardous chemicals at low temperatures and pressures are utilized. Food processing and waste water treatment facilities are typical applications for these shields. Phosphate mining is a specific application for PE Shields, and seawater desalination plants are high users of PVC Shields.

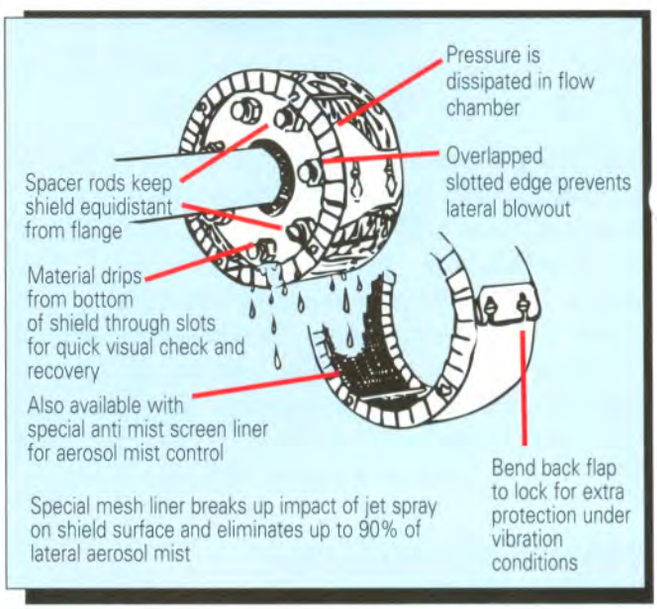
RAMCO® METAL SAFETY SHIELDS

RAMCO® uses 24 gauge steel exclusively for its metal safety shields. This gauge, approximately 25 thousandth of an inch thick, is ideal for safety shields. It is sufficiently heavy to withstand high pressures and also has flexibility to permit shaping. RAMCO® has developed specialized equipment for production of its shields, and use of its manufacturing methods results in high volume production at relatively low cost.

Three metals are used for RAMCO® Safety Shields:

- Galvanized steel
- "304" stainless steel
- "316" stainless steel

Galvanized steel is installed widely for water, oil and steam applications. The galvanized material is steel that has been coated with zinc to reduce rusting. It is vulnerable to corrosive attack and should not be used on lines carrying hazardous chemicals. When installed on vessels, it is mandatory that the shield be equipped with a special inner galvanized mesh lining that breaks up the impact of a jet spray on the shield surface, eliminating up to 90% of lateral aerosol mist.



▲ *How Metal Safety Shields Control Sprayouts*

RAMCO® uses stainless steel "304" and "316" alloys specially developed for corrosive applications. Stainless steel "304" contains 18-20% chromium and

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VALVE-GARD® SAFETY SHIELDS

Because of the wide range of harsh environments and performance requirements in the chemical processing industries, a wide selection of valves is necessary. However, approximately one-third of all chemical plant emissions come from equipment leaks — ***and valves are the biggest potential source of leaks and sprayouts.*** They are a major weak point in a piping system because they contain several areas from which leaks or sprayouts can occur.

When selecting a valve, in addition to process fluid, temperature and pressure of the line, the operating principles of the major valve groups also should be considered. And lastly, another important factor is the appropriate selection of a safety shield.

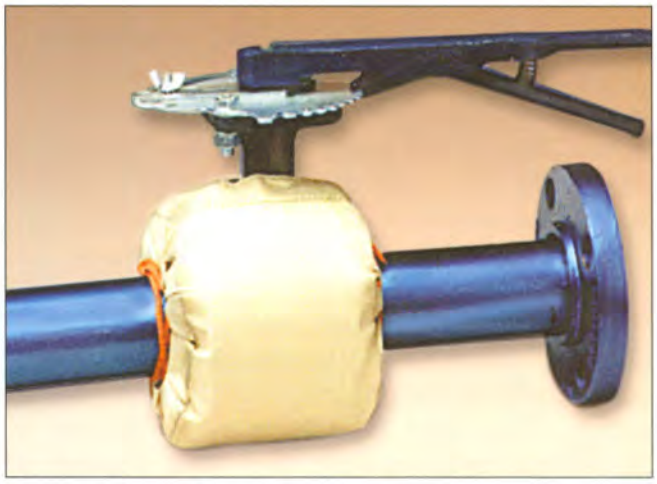
Safety shields for valves complement those for flanges, providing a system that protects employees from injuries and equipment from damage and shut-down.

▲ *RAMCO® Vue Ball Valve-Gard® Shield*

Unlike flanges, valve dimensions vary extensively, both among manufacturers and styles. Due to this wide variance in specifications, each valve shield requires its own design. To address this challenge, RAMCO® maintains an extensive library of US and International valve manufacturers. And with changes in valve technology, these data are updated.

VALVES WITH STEMS

Butterfly, ball, plug and diaphragm valves present a common design consideration in the fabrication of Valve-Gard® Shields.



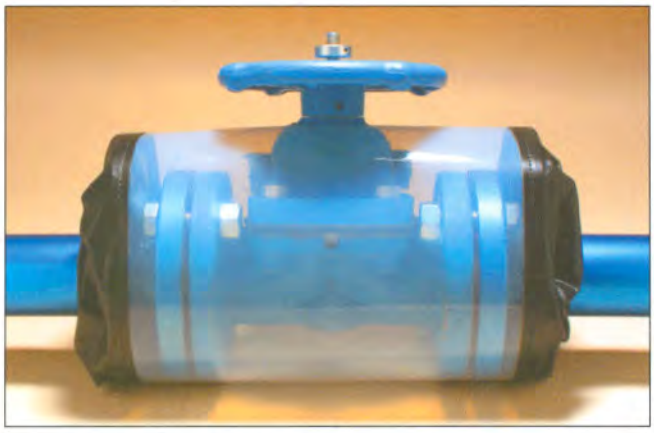
▲ *RAMCO® TFE Butterfly Valve-Gard® Shield*

The shields fabricated for these valves envelop the entire body of the valve and any mating flanges. A small opening is made for the stem to protrude for either manual or automatic operation.

▲ *RAMCO® Vue Plug Valve-Gard® Shield*

Valve-Gard® Shields are designed for installation over existing in-line valves and require no mechanical adjustment or separation of the valve from the pipeline.

Special valves with multiple ports, multi-valve configurations or valves with instrumentation can also be fitted with appropriate Valve-Gard® Shields.



▲ *RAMCO® PPL (VUE) Diaphragm Valve-Gard® Shield*

Control and actuated valves are also candidates for Valve-Gard® Shields. As long as the manufacturer's name and valve model number are provided, a safety shield can be fabricated easily.

VALVES WITHOUT STEMS

Valve-Gard® Shields are also available for most types of **check valves.** They are constructed in a similar fashion to ball and plug valves but do not require an opening for a stem. Check valve shields cover the valve and mating flanges as a single unit.

VALVES REQUIRING BONNET SHIELDS

The valves that are most frequently protected with safety shields are **gate and globe valves.** Both contain two distinct areas that are vulnerable to leaks and sprayouts — the upper portion or bonnet and the lower portion, which may be flanged or threaded.

For this valve configuration, RAMCO® recommends a combination of shields. The upper portion of the valve is protected by a specially designed safety shield which wraps around the bonnet and conveniently is called " Valve Bonnet Shield". The connecting flanges are fitted with standard flange safety shields.

▲ *RAMCO® TFE Bonnet Shield*

It should be noted that in some instances, Bonnet Shields are also used for large **diaphragm valves.**

▲ *RAMCO® Vue-Gard® Bonnet Shield*

THE ABCs OF ORDERING: VALVE-GARD® SHIELDS

To fabricate a properly fitting RAMCO® Safety Shield **for any valve,** it is necessary to know basic information:

- **pipe size**
- **type of valve**
- **its connection —**
  flanged
  threaded/socket weld
- **pressure rating**
- **valve manufacturer's name**
- **valve model number**

Similar to all flanges and other types of pipe connections, Valve-Gard® Shields for flanged, threaded or socket weld valve connections can be fabricated from a wide variety of RAMCO® materials. The most commonly used materials include:

- **TFE**
- **VUE [TFE/ECTFE]**
- **PPL**
- **PPL (VUE) [PPL/ECTFE]**
- **Metal**
  (Galvanized and Stainless Steel)

To select appropriate material for a Valve-Gard® Shield, ***it is necessary to know:***

- ***chemical*** flowing through the valve
- ***temperature*** of the chemical
- ***pressure rating*** of the system

These criteria are identical for RAMCO® Safety Shields for all pipe connections.

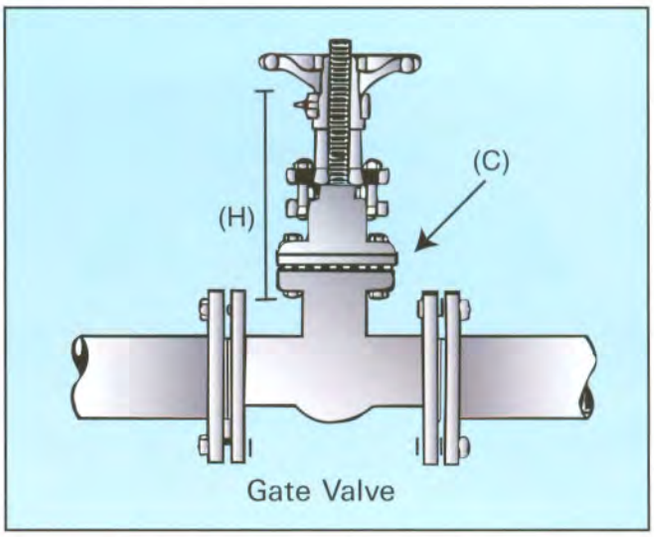
For fabrication of RAMCO® ***Valve Bonnet Shields,*** in addition to the basic information, ***two measurements of the valve are essential:***

- Height **(H)**
- Circumference **(C)**

(H) is the measurement from the base of the valve bonnet to the underside of the valve handle.

(C) is the measurement around the valve bonnet flange.

Special valve configurations require custom safety shields. For more information, contact either your local RAMCO® distributor or the RAMCO® Technical Services Group.



▲ *Measurements for Bonnet Shield*

SPECIALIZED RAMCO® SAFETY SHIELDS

In addition to a full product-line of Spra-Gard®, Econo-Gard® and Metal Safety Shields, RAMCO® produces shields that provide protection under special plant conditions:

- Expando-Gard® Shields
- Metal Drain-Gard® Shields
- Lined Drain-Gard® Shields
- Vue-Drain-Gard® Shields
- PPL (Vue) Drain-Gard® Shields
- Vue-Gard® Shields for Flow Indicators
- PPL (Vue)-Gard® Shields for Flow Indicators

EXPANDO-GARD® SHIELDS

As the name infers, Expando-Gard® Shields are specialized for use over expansion joints, regardless of manufacturer. The most frequently ordered Expando-Gard® Shield is fabricated of TFE, followed by the "See-Thru" Vue-Gard®, the PPL (Vue)-Gard®, and then, PPL. These are the only materials in which Expando-Gard® Shields are manufactured.

Expansion joints are important integral parts of piping systems but they have a tendency to leak and to create sprayouts with disquieting frequency. These joints may have convolutions of rubber, plastic or stainless steel, and Expando-Gard® Shields are suitable for all three types, regardless of manufacturer.

Effective shielding of an expansion joint must envelop the piping connection and must, at the same time, have the ability to retain its position firmly, even when exposed to intense pressure, as in the case of a surging leak.

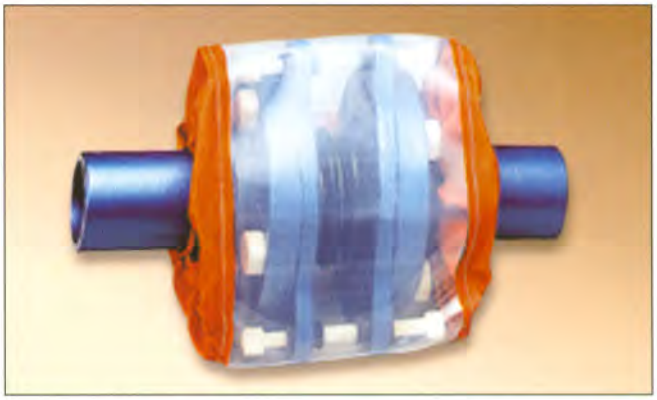
A flange has a fixed configuration and accordingly, to design a shield with a tight fit is relatively simple. In contrast, an expansion joint expands, contracts and misaligns. The RAMCO® Expando-Gard® Shield provides for these dimensional changes without inhibiting the motion of this device. This innovative shield wraps around and fits snuggly over the joint, providing the needed protection in the event of a hazardous chemical leak.

An early leak can be detected by the indicating patch on the Expando-Gard® Shield (except for the "See-Thru" Shields). This patch changes color immediately on exposure to an acid or base. As with all RAMCO® Shields, the materials that are used in the manufacture of the Expando-Gard® Shields are non-flammable and non-combustible, including the tie-cords.

Expando-Gard® Shields may be produced for any pipe size or may be customized to any non-standard specification. To fabricate Expando-Gard® Shields of any RAMCO® material, the following information is required:

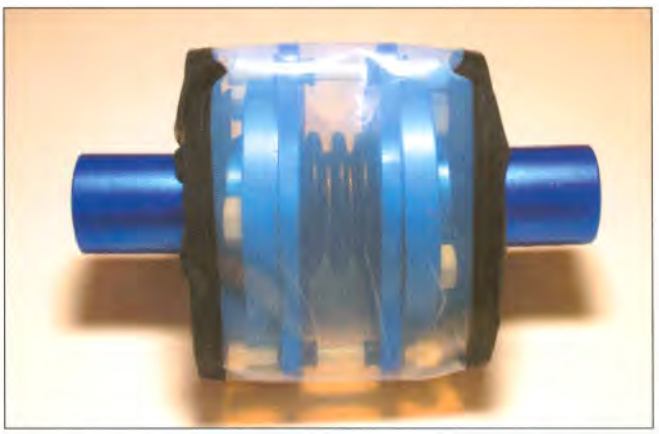
- Face-to-Face of the expansion joint (nominal length)
- Pipe size
- Number of convolutions
- Number of limit bolts (control rods)

These unique, specialized shields are installed with ease, and just as with flange safety shields, no tools are required.



▲ *RAMCO® Vue Expando-Gard® Shield*

This RAMCO® Safety Shield has been recognized as contributing significantly to the advancement of safety in chemical processing. It was given the National John C.Vaaler Award as "a major contribution toward more efficient and effective operation of plants in the chemical processing industries".



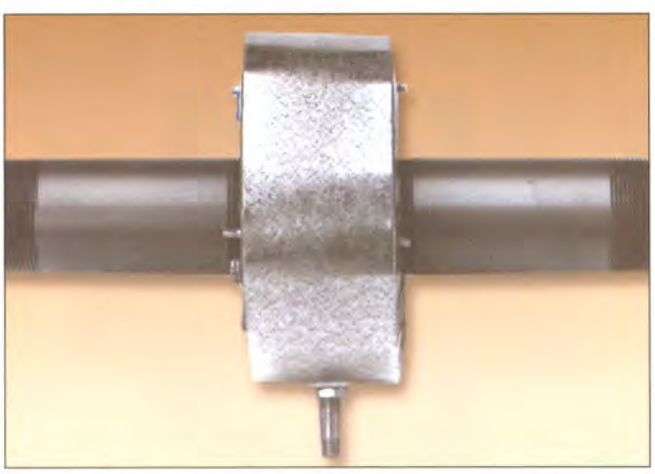
▲ *RAMCO® PPL (Vue) Expando-Gard® Shield*

METAL DRAIN-GARD® SHIELDS

The Drain-Gard® Shield is a very useful safety device in situations in which ***spills must be avoided.*** Such conditions include:

(1) piping connections located directly over walkways
(2) piping systems used for unloading barges, tankers and trailers to prevent spills into waterways
(3) installation under pipe insulation
(4) recapture of chemicals and corrosives and directing spillage to recovery containers
(5) secondary containment

Constructed in either "304" or "316" stainless steel, the Drain-Gard® Shield is produced in all pipe sizes. All elements in its construction are stainless steel. Its basic design is similar to a metal safety shield with overlapping slotted edges to prevent lateral sprayout and inner spacer rods to create a flow space to dissipate pressure. In addition, the lower portion of the shield is equipped with a threaded nipple to accommodate a hose or pipe connection, providing retrieval and secondary containment. In the event of a gasket failure, the leaking fluid will not flow over the sides of the safety shield, but the chemical will drain through the nipple into the attached connection and receptacle. This shield can be customized with an alarm to signal a leak alert.

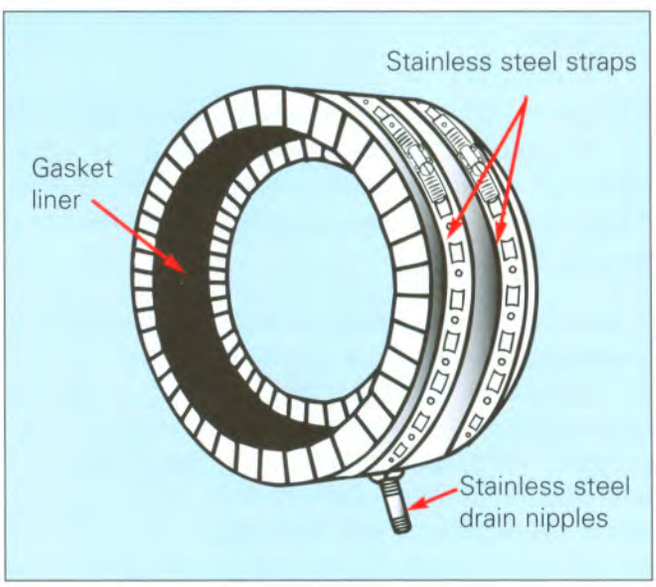


▲ *RAMCO® Metal Drain-Gard® Shield*

This novel safety shield can be manufactured for valves as well as flanges. It is also possible to develop customized versions. Regardless of configuration, they are easily installed with the use of only a screwdriver.

LINED DRAIN-GARD® SHIELDS

Constructed of 24 gauge "304" or "316" stainless steel, this Drain-Gard® Shield is fitted with a special gasket liner. Among the various liners that may be used are Buna-N or TFE.



▲ *RAMCO® Lined Drain-Gard® Shield*

The shields can be installed easily by slipping them over the existing pipe connections. Then, they are drawn tightly over the outside diameter of the flanges by stainless steel straps. They can be installed quickly with only the use of a screwdriver.

In the event a liquid or vapor escape, the leaking chemical is channeled between the flanges to the nipple for retrieval. As with the Drain-Gard® Shield, this shield can be fitted with an alarm to signal a leak alert.

"SEE-THRU" SPRA-GARD® SHIELDS

Among the Spra-Gard® Shields are the innovative "See-Thru" Safety Shields that permit easy identification and inspection of all pipe joints, including flanges, valves and expansion joints.

Constructed of a clear film (ECTFE) bordered by either TFE coated fiberglass that is burnt orange in color or PPL, the Vue-Gard® and the PPL (Vue)-Gard® Safety Shields permit visual inspection of pipe joints by personnel so leaks can be detected rapidly. These "See-Thru" Shields clearly contribute to a safe processing plant environment.

RAMCO®'s unique viewing shields withstand temperatures up to 300°F (150°C) and pressures to 1000 psi (69 bar) for the Vue-Gard® Shield and 225°F (107°C) and 1000 psi (69 bar) for the PPL (Vue)-Gard® Shield. They demontrate a broad spectrum of chemical resistance, especially to most corrosive chemicals and organic solvents.

Similar in construction to the other Spra-Gard® Shields, the overlap design of "See-Thru" Shields completely encompasses the pipe connection down to the outside diameter of the pipe. Accordingly, both frontal and lateral sprayouts in systems carrying hazardous or toxic chemicals, even under high pressure conditions, are contained.

Because of their novel characteristics, these shields demonstrate a wide scope of applications in the chemical processing industries. In addition to chemical and pharmaceutical uses, they are appropriate in refineries as well as pulp and paper operations.

PPL (VUE)-DRAIN-GARD® SHIELDS

Because of the versatility of these shields, they have been modified for special applications in the chemical processing industries. The "Drain-Gard" concept of the stainless steel shield has been adapted to the Vue-Gard® and the PPL (Vue)-Gard® Safety Shields.

▲ *RAMCO® PPL (Vue)-Drain-Gard® Shield*

Not only do these shields permit visual inspection of pipe joints and mitigate the effects of hazardous chemical sprayouts, but they also allow recapture of toxic chemicals from leaking flanges and valves. The TFE nipple accommodates a connection for retrieval and secondary containment. And the port permits insertion of a "sniffer" to read fugitive emissions.

Both of these Drain-Gard® Shields are available for flanges and valves and can be manufactured for both standard and customized sizes to meet specific requirements.

"SEE-THRU" SPRA-GARD® SAFETY SHIELDS FOR FLOW INDICATORS

An ideal application of the "See-Thru" Safety Shield is its customized fabrication for use with sight flow indicators. The clear design of the shield allows easy visualization of the sight window and sight window retainers. The proximal pipe connections are also shielded.

▲ *RAMCO® Vue-Gard® Shield For Flow Indicator*

The overlap feature wraps around the sight flow indicator, thereby, preventing lateral sprayouts. And yet, visualization is not impeded. The Vue-Gard® and the PPL (Vue)-Gard® Shields can be fabricated for all flow indicators, regardless of size and manufacturer.

OTHER APPLICATIONS

Since the availability of the RAMCO® "See-Thru" Spra-Gard® Safety Shields, customized versions of these shields have been fabricated for pressure vessels, heat exchangers and various instruments in chemical, pharmaceutical, pulp and paper plants as well as utility facilities.

RAMCO® SAFETY SHIELDS FOR THREADED FITTINGS

RAMCO® has developed safety shields for threaded fittings, such as elbows, couplings, unions and tees. They are available in **Econo-Gards®** — PVC and PE — and **Spra-Gards®** — TFE, Vue-Gard®, PPL (Vue)-Gard® and PPL materials. Metal Safety Shields are available for unions and couplings only.

Similar to Spra-Gard® Shields and Econo-Gard® Safety Shields, shields for threaded fittings contain pH indicating patches, velcro fasteners and tie cords. Since the "See-Thru" Shields permit direct visualization of the threaded connection, an indicating patch is not needed.

These shields, regardless of configuration, are installed easily without tools.

▲ *RAMCO® Vue Tee Safety Shield*

MARINE APPLICATIONS

Based on extensive experience in supplying safety shields to the US Navy, US Coast Guard and other navies worldwide, RAMCO® has expanded its scope to include safety shields for the commercial marine industry. By demonstrating its capability to meet the needs and solve problems for end-users, RAMCO® has become the provider of choice for many international shipping lines.

SOLAS Regulation 15.2.11 requires that fuel oil lines shall be protected to prevent oil spray and oil leaks

onto hot surfaces, into machinery air intakes, or other sources of ignition. RAMCO® Shields on engine room piping and valves that carry fuel oil, lube oil and other flammable petroleum products prevent fire from hazardous oil spray-outs and ensures safety for shipboard personnel and equipment.

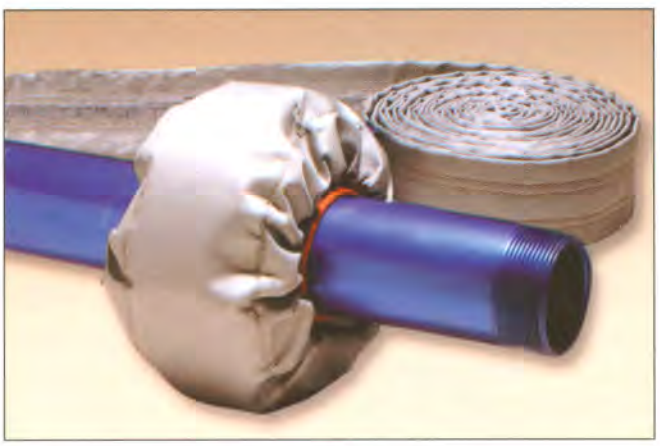
TFE SPRA-GARD® SAFETY SHIELDS

The TFE Spra-Gard® Safety Shield has met the requirements of ABS Product Type Approval for Safety Shields. Accordingly, this shield has been certified by ABS and awarded a Certificate of Type Approval (RQS) - Certificate Number NY283534-X.

In addition to its installation in engine rooms, these safety devices are useful on piping and valves onboard chemical carriers where hazardous and/or toxic agents are present. The shields act as a barrier to prevent sprayouts from injuring people or damaging equipment. (For more information on this shield see page 7).

RAMCO® NAVY SPRAY SHIELD

This specially designed and fabricated safety shield is used in engineering spaces on naval and commercial vessels. These shields are installed around mechanical joints — flange connections, bolted unions, valves, etc. — in liquid piping systems. In the event of a leak in a joint, this safety product prevents both the contact of flammable liquid on hot surfaces and the dripping of fluid into electrical switch-boards/components.



▲ *RAMCO® Navy Shield*

RAMCO® Navy Spray Shields are fabricated in 20 and 30 foot rolls according to the strict standards outlined in the American Society for Testing and Materials Standards, as well as various military specifications throughout the world. RAMCO® ensures that all shields are designed and manufactured in conformance to required specifications.

These specialized shields contain two layers. The first, an inner layer of aluminum laminated to fiberglass, resists heat, chemicals and moisture. The second, a high temperature resistant, flame retardant outer layer of silicone rubber and fiberglass, is designed as a protective cover to provide greater life and improved resistance to abrasion, flexing, tear and puncture. These two layers are sewn together by TFE-coated fiberglass thread that is unaffected by fungi, is resistant to most chemicals and will not burn or support combustion in normal atmospheres.

To manufacture a RAMCO® Navy Spray Shield basic information is required:

- **pipe size**
- **type of fitting to be covered**
- **and/or the dimensions of any special fitting**

This shield is installed easily by wrapping it around the fitting or valve and securing it simply by twisting the ends of lacing wire together tightly. A snug fit is essential.

RAMCO® Navy Spray Shields are economical, maintenance-free and contribute to engine room safety. These life-saving devices are installed in merchant, naval and passenger vessels in many countries.

SELECTING THE RIGHT TYPE OF SHIELD

To simplify the task for the engineer or piping designer of selecting the appropriate RAMCO® Safety Shield from the wide variety that is available, a **Chemical Resistance Guide** is provided (See Section 3). Also, a comparative **Matching Method** follows that describes guidelines for the selection of an appropriate shield. These safety recommendations are based on currently available technology.

The **Chemical Resistance Guide** contains suggestions for approximately 160 frequently used liquid chemicals. These recommendations are based on laboratory tests, performance reports and published data.

Temperature limitations, as shown, are conservative to provide a reasonable safety margin. For example, PE has been limited in the selection guide to 140° F (60°C), but in actual laboratory testing, it has tolerated temperatures as high as 200°F (93°C). This down rating applies to all RAMCO® materials. While RAMCO® Safety Shields may be used at temperatures slightly above those in the chemical resistance guide without experiencing degradation, this practice is not recommended.

Just a word of caution. The suggestions provided in the guide should be qualified and adjusted according to local conditions that can vary among plant environments. Accordingly, engineers and piping designers must consider local variances for the proper selection of a safety shield.

Technical assistance for information on chemicals that do not appear in this Resistance Guide is available from the RAMCO® Technical Services Group.

In addition to the Chemical Resistance Guide, a simple method to determine which kind of safety shield is suitable for a particular application may be considered. By the **Matching Method,** the material of the shield is matched to the material of the piping system. Since extensive engineering knowledge, experience and skill have already been applied to select the most desirable type of piping for a line, this information could be applied to the selection of the appropriate safety shield. The wide variety of materials that are used in the RAMCO® productline makes this practice possible.

By matching the safety shield to the pipe lining, one can specify TFE Spra-Gard® Shields for TFE-lined piping systems and install PPL Spra-Gard® Shields on PPL-lined piping. If an entire plant uses stainless steel, then RAMCO® Stainless Steel Safety Shields are appropriate. For unlined carbon steel pipe, matching is not possible, and the choice of shield should be based on the criteria in the Chemical Resistance Guide.

There are instances, however, in which shield to piping mismatching appears to work satisfactorily. For example, PE Econo-Gard® Shields are working well for phosphate operations in Florida, even though stainless steel piping is usually installed in these plants.

If mismatching is being considered for economic reasons, testing is strongly recommended before such a decision is made. RAMCO® will be happy to provide samples of materials for this purpose free of charge.

PRODUCT PART NUMBERS

SHIELDS FOR FLANGES

For product identification, RAMCO® uses a three-part code system. The first three or four digits identify the material from which the shield is made —TFE, VUE, PPL, PVCR etc. The second part denotes the pressure rating of the pipeline, such as 150 psi and the third, gives the pipe size.

An example for a flange shield is:

PPL-150-2:

- "PPL" indicates the material from which the shield is made
- "150" is the pipe pressure rating
- "2" is the pipe size

Frequently used RAMCO® product identification codes follow:

- ***FIRST DIGIT GROUPING:***

  TFE - fluorocarbon coated fiberglass
  VUE - TFE/ECTFE
  PPL - polypropylene
  PPLV - PPL/ECTFE
  PVCR polyvinyl chloride (red)
  PVCW polyvinyl chloride (white)
  PVCC polyvinyl chloride (clear)
  PE - polyethylene
  304 - "304" stainless steel
  316 - "316" stainless steel
  GAL - galvanized steel

- ***SECOND DIGIT GROUPING:***

  150 - 150 psi
  300 - 300 psi
  600 - 600 psi
  900 - 900 psi
  1500 - 1500 psi
  3000 - 3000 psi
  TEE - Tee
  CPG - Coupling
  ELB - Elbow
  UNI - Union

- ***THIRD DIGIT GROUPING:***

  From 1/4" up to 60" Pipe Size

Metal shields, galvanized and stainless steel, for special conditions may be fitted with a mesh liner (M). An example of the product code for a "304" flange shield for a 3" pipe with a mesh liner and a pressure rating of 600 psi is:

304M-600-3

If a mesh liner is not required, the product code is:

304-600-3

EXPANDO-GARD® SHIELDS

As with flanges, the first digit grouping identifies the material of the Expando-Gard® Shield. The second grouping is EXP. The first set of numbers after EXP indicates the number of convolutions (1-10) of the joint and the following group, the pipe size (1/2" - 60+"). An example for a 20" 8 convolution expansion joint that is to be shielded in TFE (See page 15) is:

TFE-EXP-8-20

VALVE BONNET SHIELDS

Valve Bonnet Shields are specially designed for gate and globe valves. And in some instances, Bonnet Shields are used for large diaphragm valves.

The product code describes the material from which the shield is made followed by the two essential measurements of the valve — Height and Circumference. (See page13).

An example for a 2" gate valve with an 8" height and a 16" circumference that is to be shielded with VUE (TFE/ECTFE) is:

VUE-816

VALVE-GARD® SHIELDS

Because of the wide variety of valves and valve manufacturers, product codes for valve shields are quite complex. To keep it simple, we suggest that the basic information be provided:

- **pipe size**
- **type of valve**
- **its connection —**
  flanged
  threaded/socket weld
- **pressure rating**
- **valve manufacturer's name**
- **valve model number**

METAL DRAIN GARD® SHIELDS

For flange Drain-Gard® Shields, the product code is similar to that for flange shields. Since they are fabricated in either "304" or "316" stainless steel, the first group of digits includes either set of numbers followed by "D". This is followed by the pressure rating of the system and lastly, the pipe size.

The product code of a RAMCO® Drain-Gard® Shield for a 4" 300 psi flange in "316" is:

316D-300-4

METAL LINED DRAIN-GARD® SHIELDS

The product code for this shield is similar to the Drain-Gard® Shield except "L" is used to signify the shield lining. An example of a 2" 600 psi "304" stainless steel lined Drain-Gard® is:

304LD-600-2

The type of lining must be stated since it is not part of the product code.

"SEE THRU" DRAIN-GARD® SHIELDS

Not only are the Vue- and the PPL (Vue)-Drain-Gard® Shields available for flanges, but they can be fabricated for valves, expansion joints and other fittings. The product codes for either thermoplastic material for a 3" 150 psi flange are:

VDG-150-3

PPVD-150-3

Product codes for other joint connections warrant discussion with local distributors or RAMCO® personnel.

LEST YOU FORGET....

To select the appropriate RAMCO® Safety Shields for any pipe connection, ***it is necessary to know:***

- **chemical** flowing though the valve
- **temperature** of the chemical
- **pressure rating** of the system

For special or custom shield fabrication technical assistance is available from the RAMCO® Technical Services Group.

INSTALLATION OF RAMCO® SAFETY SHIELDS

Installing a RAMCO® Safety Shield is both simple and rapid, usually requiring less than a minute. Whether a shield is placed over a flange, valve or fitting, the method of installation is the same.

The complete line of RAMCO® Shields, produced from either thermoplastics or metals, are wrap-arounds. The difference between the two groups is the method of securing them on the pipe connection or valve. Fabric shields are fastened securely by tie-down cords; whereas, metal shields are held firmly in place by metal screws or bands.

All shields are shipped directly from the RAMCO® plant ready for installation. Each package of shields includes installation instructions for quick reference. Thermoplastic shields require no tools for installation, and metal shields need only the use of a Phillips screwdriver.

INSTALLING THERMOPLASTIC SAFETY SHIELDS

Incorporated within each RAMCO® thermoplastic shield is a velcro fastener that holds the shield in place over a flange, pipe connection or valve allowing installation of the shield by a single worker in less than a minute.

Four installation steps follow:

1. Wrap the safety shield tightly around the flange, valve or fitting.
2. Press the two portions of the velcro fastener together to close the shield.
3. Pull the tie cords together tightly on each side, take one or two turns around the pipe and fasten over the pipe with a square knot.

NOTE: ONLY A SQUARE KNOT SHOULD BE USED.

In the event of a leak, a square knot tightens when subjected to pressure, avoiding the risk that the shield loosens and slides off the fitting or valve. If incorrectly tied, a granny knot results and under pressure, this knot becomes untied allowing the shield to be ineffective in preventing a sprayout.

4. Do not cut the tie cords but tuck them between the flange and shield.

SQUARE KNOT

GRANNY KNOT

The **SQUARE KNOT,** or **REEF KNOT,** is used in reefing (temporarily reducing the area of a sail), in tying up bundles of all kinds, and for many other purposes. It is insecure if the two cords are of different sizes or materials.

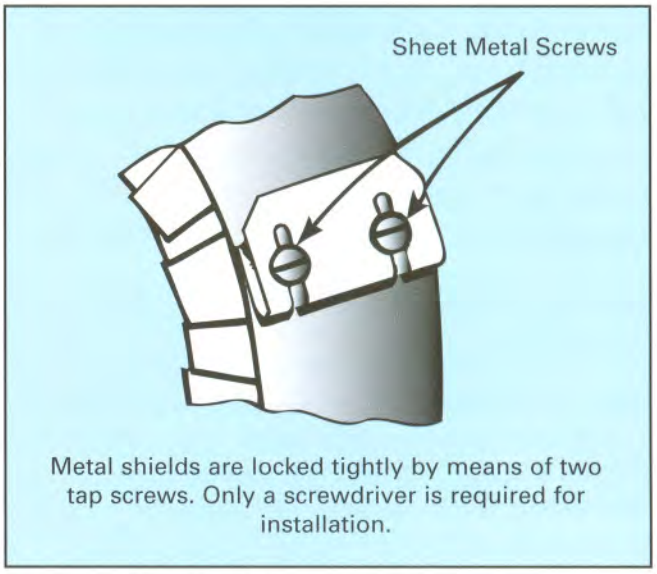
The **GRANNY KNOT,** or **LUBBERS KNOT,** is sometimes tied by mistake instead of a square knot. It is unsafe, however, and should always be avoided.

▲ *Square Knot vs. Granny Knot*

INSTALLING METAL SHIELDS

Installation instructions are as follows:

1. Loosen the two sheet metal screws.
2. Wrap the safety shield around the flange, valve or fitting.
3. Place the two screws through the slots provided in the shield. The shield is positioned correctly but fits loosely.
4. Press the ends of the shield firmly together so the shield fits tightly around the connection or valve.
5. Secure the shield by tightening the screws using a Phillips screwdriver.
6. Bend back the flap of the shield 180° to lock.



Metal shields are locked tightly by means of two tap screws. Only a screwdriver is required for installation.

▲ *RAMCO® Metal Safety Shield*

THAT'S IT IN A NUT SHELL FOR INSTALLING RAMCO® SAFETY SHIELDS....

These unique safety devices installed over flanges, pipe fittings and valves contribute to a safe work

environment. In the event of a leak, the indicating patch in each thermoplastic shield (except the "See-Thru" Shields, of course) will turn color signaling an alert. These shields will contain and deflect temporarily the escaping hazardous, toxic chemical, and thereby, mitigate the effects of a potentially devastating sprayout.

REGULATORY STANDARDS AND SAFETY SHIELDS

Concern for safety in the workplace is an ethical and legal issue, as well as an economic factor, since a safe work environment contributes to a cost-effective plant operation. Safety shields play a role in working towards this goal. By contributing to a safe plant setting, these safety devices reduce the danger of chemical sprayouts. This, in turn, reduces personnel absenteeism, lowers workmen's compensation claims and minimizes the cost of replacement worker training.

Excerpts follow from documents of major organizations that are involved with industries that process hazardous chemicals as well as those from the maritime organizations. These excerpts focus on personnel and environmental safety and measures to achieve this end. RAMCO® Safety Shields, may be considered one means of protection under these standards.

This section is not a complete discussion of safety regulations and standards and should not be construed as a legal interpretation.

OSHA

(Occupational Safety and Health Administration of the US Department of Labor)

Frequently, questions arise concerning RAMCO® Safety Shields as they relate to the safety requirements of OSHA.

It is the policy of OSHA not to approve or endorse specific products or texts that are prepared by the private business sector. Accordingly, RAMCO® Manufacturing Company, Inc. does not presume to speak for or interpret policies, regulations and rulings authorized by OSHA in this manual. In order to assure that these precepts are not compromised, published OSHA standards and pronouncements that appear to be related to this topic are quoted below.

Section 1910.132 of OSHA Safety and Standards (29 CRF 1910) was revised as of July 1, 1993. This reference discusses the use of various protective devices wherever and whenever necessary due to hazards. And among these hazards chemicals are cited:

"1910.132 General Requirements

(a) Application. Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory de-vices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact."

"General Duty Clause", Section 5(a)(1) of the Occupational Safety and Health Act of 1970, which is still currently in effect, also is noteworthy:

"Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."

"Review Commission and court precedent have established that the following elements are necessary to prove a violation of the general duty clause:

1. The employer failed to keep the work place free of a hazard to which employees of that employer were exposed;
2. The hazard was recognized;
3. The hazard was causing or was likely to cause death or serious physical harm; and
4. There was a feasible and useful method to correct the hazard."

Further expansion on point 4:

"To establish a Section 5 (a) (1) violation the agency must identify a method which is feasible and likely to correct the hazard... Feasible and useful abatement methods can be established by reference to:

1. The employer's own abatement method which existed prior to the inspection but was not implemented;
2. The implementation of feasible abatement measures by the employer after the accident or inspection;
3. The implementation of abatement measures by other companies;
4. The recommendations by the manufacturer of the hazardous equipment involved in the case; and
5. Suggested abatement methods contained in trade journals, private standards and individual employer standards...
6. Evidence provided by expert witnesses which demonstrates the feasibility of the abatement methods. Although it is not necessary to establish that the industry recognizes a particular abatement method, such evidence shall be used if available."

ANSI

(American National Standards Institute)

The need for a national code for pressure piping was identified as early as 1925 in the United States. And to meet this need, the American Standards Association began project B31 in 1926 under the sponsorship of the American Society of Mechanical Engineers (ASME). Through the years, this code has been amended by the American National Standards Institute, a private standard-setting organization. ANSI/ASME B31.3 1990 contains relevant information with regard to safety shields:

"APPENDIX G SAFEGUARDING

G300 SCOPE

(a) Safeguarding is the provision of protective measures to minimize the risk of accidental damage to the piping or to minimize the harmful consequences of possible piping failure...

G300.1 GENERAL CONSIDERATIONS

In evaluating a piping installation design to determine what safeguarding may exist or is necessary, the following should be reviewed:

(a) the hazardous properties of the fluid, considered under the most severe combination of temperature, pressure, and composition in the range of expected operating conditions;

(b) the quantity of fluid which could be released by piping failure, considered in relation to the environment, recognizing the possible hazards ranging from large releases of otherwise innocuous fluids to small leakages of toxic fluids;

(c) expected conditions in the environment, evaluated for their possible effect on the hazards caused by a possible piping failure.

(d) the probable... sources of damage to the piping from direct or indirect causes;

(e) the probable need for grounding of static charges to prevent ignition of flammable vapors; ...

G300.3 ENGINEERED SAFEGUARDS

Engineered safeguards which may be evaluated and selectively applied to provide added safeguarding include:

(a) means to protect piping against possible failures, such as:

(1) thermal insulation, shields, or process controls to protect from excessively high or low temperature and thermal shock;

(2) armor, guards, barricades, or other protection from mechanical abuse; .

(b) means to protect people and property against harmful consequences of possible piping failure, such as confining and safely disposing of escaped fluid by shields for flanged joints, valve bonnets, gages, or sight glasses; or for the entire piping system if of frangible material; ..."

CMA

(Chemcial Manufacturers Association)

In 1988, the Board and member companies of CMA adopted an initiative called Responsible Care: A Public Commitment. This initiative commits all member companies to improve the industry's responsible management of chemicals in response to public concerns about the impact of chemicals on health, safety and environmental quality.

Developed and implemented are six Management Practice Codes. The codes focus on practices in specific areas of chemical manufacturing, transporting and handling that CMA member companies agree to make continuous "good-faith efforts" to attain.

They include:

- CAER - Community Awareness & Emergency Response
- Pollution Prevention
- Process Safety
- Distribution
- Employee Health and Safety
- Product Stewardship

A key element to this program is self-evaluation. Periodically, member companies must report measurements of program implementation, showing improved environmental, health and safety performance in managing chemicals.

AMERICAN BUREAU OF SHIPPING

Two concerns for safety in the shipping industry are identified in:

Section 34.37.2 Shielding of High Pressure Fuel-Oil Piping

"On all main and auxiliary engines having a cylinder bore of 250mm (10 inches) and above, the high pressure fuel-oil injection piping is to be effectively shielded and secured to prevent fuel or fuel mist from reaching a source of ignition on the engine or its surroundings. Suitable arrangements are to be made for draining any oil-fuel leakage and for preventing contamination of lubrication oil by fuel oil..."

Section 41.79.1 Fire Precaution

"To minimize the outbreak of fire from oil spray, the following precaution is to be taken where necessary:

b) Pressurized diesel fuel and lubrication oil lines are to have safety shields around flanges near ignition sources."

U.S. COAST GUARD DEPARTMENT OF TRANSPORTATION

Emphasis on safety is documented in the Marine Engineering Regulations - Subchapter F:

Section 56.50-5 Systems Conveying Oil

"(D) Piping conveying oil shall be run well away from hot surfaces wherever possible . . . suitable shields shall be fitted in the way of flanges or mechanical pipe joints when welded joints are not practicable."

Section 56.50-65 Boiler Fuel Oil Service Systems

"(C) ...all bolted flange joints shall be provided with a wrap around deflector to deflect spray in case of a leak."

RAMCO®

"ASSURING SAFETY REQUIRES QUALITY BEYOND DOUBT... ANYTHING ELSE INVOLVES RISK"

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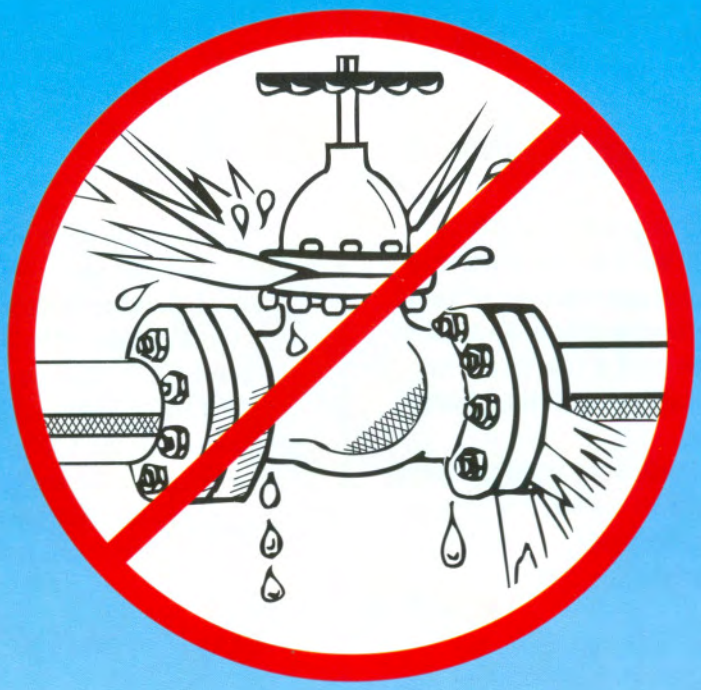

SECTION

3

SYSTEM CERTIFICATION
ISO 9001:2000 SGS

SELECTION GUIDE: FREQUENTLY USED LIQUID CHEMICALS

SULFURIC ACID

Sulfuric acid, one of the most important, highly corrosives of all industrial chemicals, can be dangerous. Pipe lines carrying sulfuric acid are commonly found in numerous chemical processing plants as well as other industrial facilities. This acid is one of the highest volume chemicals produced in the United States.

The hazardous nature of sulfuric acid is demonstrated by adding a drop of water to concentrated acid. This mixture creates an intense heat evolution sufficient to soften most plastic materials.

For piping systems carrying sulfuric acid, the TFE Spra-Gard® Shield is the RAMCO® Safety Shield that is specified most frequently. It can resist sulfuric acid at any concentration including the fuming form, oleum. Only this RAMCO® Shield can be used in this fashion. Others are suitable within certain limitations. At temperatures higher than 450° F (232° C), stainless steel is mandatory, although some corrosive attack and pitting may occur.

For dilute sulfuric acid, 30% or less, PPL and PPL (Vue) Spra-Gard® Shields can be used at temperatures up to 200° F (93° C). PE and PVC Econo-Gard® Shields are recommended at temperatures up to 140° F (60° C).

At ambient temperatures, TFE, Vue, PPL and PPL (Vue) Spra-Gard® Shields can be used for concentrated sulfuric acid, 93% or 98%. In laboratory tests at these concentrations, PVC and PE Econo-Gard® Shields suffered degradation and consequently, are not recommended.

AMMONIA

Ammonia is among the chemicals considered by the Occupational Safety and Health Administration (OSHA), to be a recognized hazard and is listed as such in the agency's "General Industry Safety and Health Standards". Safety shields frequently are specified to protect against leaks and sprayouts in ammonia lines.

RAMCO®'s low cost PE Econo-Gard® Shield is resistant to ammonia at ambient temperatures and many of its compounds at temperatures up to 140° F (60° C). PPL and PPL (Vue) Spra-Gard® Shields can be used on ammonia lines at temperatures up to 225° F (107° C) while, the TFE Spra-Gard® Shield is suggested up to 450° F (232° C) temperatures. For higher temperatures, "304" and "316" stainless steel show excellent resistance to ammonia and most of its compounds.

PHOSPHORIC ACID

Although the acid associated with phosphorus is usually referred to as phosphoric acid, a group of several different acids are formed from phosphorus:

- metaphosphoric acid (HPO_3)
- orthophosphoric acid (H_3PO_4)
- diphosphoric acid ($H_4P_2O_7$)
- phosphorous acid (H_3PO_3)

While these are considered strong acids, they are weaker than sulfuric acid. They do not have the powerful oxidizing properties of sulfuric acid and also are less volatile.

The complete RAMCO® Safety Shield product-line — except galvanized steel — is suitable for installation with these acid lines. The Econo-Gard® Shields, PVC and PE, are appropriate for concentrations up to 85% for temperatures up to 140° F (60° C).

TFE Spra-Gard® Shields are resistant at all concentrations with temperature limitations of 450°F (232°C), and the Stainless Steel Safety Shields can be used at higher temperatures.

OXIDES AND HYDROXIDES

Sodium hydroxide, also known as caustic soda, is the most important commercial caustic. Several other oxides — sodium hydroxide, lithium hydride, calcium oxide, barium (soluble compounds) — are classified by OSHA, the United States Occupational Safety and Health Administration, as recognized hazards.

Many of the RAMCO® Safety Shields are effective in shielding piping connections of these chemical lines at varying temperatures. Because of the number of chemicals in these categories, it is advisable to select the appropriate RAMCO® material for a safety shield from the Chemical Resistance Guide that follows.

ACETONE

Acetone, an important and widely used chemical, is a strong solvent that is highly flammable. It is popular as a paint and varnish remover and also is used extensively in the manufacture of various chemicals and drugs.

For systems using this chemical, Spra-Gard® Shields and RAMCO® Stainless Steel Shields are advised. While PPL and PPL (Vue) Shields may be used up to 121° F (49° C), TFE Shields may be used up to 450° F (232° C). Above this temperature, "304" or "316" RAMCO® Shields, seem particularly suitable for such applications.

HYDROFLUORIC ACID

Hydrofluoric acid, hydrogen fluoride in an aqueous solution, is very violent and extremely hazardous. The element fluorine, a strong oxidizing agent, reacts violently with water and is toxic.

Although this acid is not frequently used, in contact with glass it reacts intensely and consequently, is used to etch glass. Hyrdofluoric acid is also used in petroleum cracking operations.

Because of the potential harm of this acid, shielding of its piping systems is strongly advised. RAMCO® PPL and PPL (Vue) Spra-Gard® Shields are recommended for concentrations up to 60% and temperatures up to 200° F (93°C). Above this concentration or temperature, only RAMCO® "316" Stainless Steel Shields are indicated.

STEAM AND LUBRICATING OIL

Other extremely dangerous conditions, in the event of a leak/sprayout, are piping systems carrying live steam under pressure or hot oil applications.

To provide effective shielding, either RAMCO® Galvanized Shields or the Navy Spray Shields are recommended.

"LIQUORS"

Three types of liquors (any aqueous solution of one or more chemical compounds) are used extensively in the pulp and paper industries. Black liquor, also called spent sulfate liquor, is liquid digester waste containing sulfonated lignin, rosin acids and other waste-wood components from which tall oil is made. Green liquor is a solution made by dissolving chemicals that are recovered in the alkaline pulping process in water, and white liquor is made by adding caustic soda to a sodium sulfide solution.

Because of the hazardous nature of the chemicals in these liquors, RAMCO® Safety Shields are commonly installed in pulp and paper manufacturing plants. The TFE Spra-Gard® and the Vue-Gard® Shields are the shields of choice because of their wide spectrum of chemical resistance.

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CHEMICAL RESISTANCE GUIDE

Environmental conditions in industrial plants may vary and thus, affect material performance. Since chemical attack and resistance are very complex phenomena, this Chemical Resistence Guide is intended only as a "guide" subject to adjustment by engineers and piping designers for local conditions and individual industrial plant experience.

The data presented in the following table were obtained from various sources. In addition to the testing that has been conducted by the United States Testing Company at the request of RAMCO® Manufacturing Company, Inc., field reports from end-users concerning the performance of the RAMCO® Safety Shields have been incorporated. And lastly, source material from suppliers and the published literature has been utilized.

Consequently, it is the end-user and not the manufacturer who assumes all responsibility and risk for proper evaluation, application and performance of safety shields for any and all specific uses.

Symbols used in this guide include:

PVC Polyvinyl Chloride Econo-Gard® Shield
PE Polyethylene Econo-Gard® Shield
PPL Polypropylene Spra-Gard® Shield
VUE TFE/ECTFE Spra-Gard® Shield
TFE Teflon Spra-Gard® Shield
304 "304" Stainless Steel Shield
316 "316" Stainless Steel Shield
NR Not Recommended
..... No Data Available

MAXIMUM TEMPERATURE (°F) RAMCO® SAFETY SHIELDS

CORROSIVE STREAM	PVC	PE	PPL*	VUE	TFE	304	316
Acetaldehyde	NR	NR	75	.....	450	.....	.....
Acetic acid (10%)	140	140	200	212	450	500+	500+
Acetic acid (50%)	140	140	200	212	450	500+	500+
Acetic acid (80%)	73	70	125	300	450	500+	500+
Acetic acid (glacial)	NR	70	125	212	450	500+	500+
Acetone (10-100%)	NR	NR	125	121	450	500+	500+
Acetophenone	NR	NR	75	121	450	500+	500+
Acetyl chloride	NR	.....	NR	121	450	500+	500+
Acetylene tetrabromide	NR	.....	NR	.....	450	.....	.....
Acetylene tetrachloride	NR	.....	NR	.....	450	500+	500+
Aluminum chloride	140	140	225	300	450	.....	.....
Aluminum hydroxide	140	.....	200	300	450	500+	500+
Aluminum nitrate	140	.....	200	300	450	500+	500+
Aluminum oxychloride	140	.....	125	300	450	.....	.....
Aluminum sulfate	140	140	225	300	450	500+	500+

*** NOTE: The chemical resistance of PPL (Vue) Spra-Gard® Shields is consistent with the data for PPL Shields.**

RAMCO®

MAXIMUM TEMPERATURE (°F)
RAMCO® SAFETY SHIELDS

CORROSIVE STREAM	PVC	PE	PPL*	VUE	TFE	304	316
Ammonia (liquid)	NR	70	225	.....	450	500+	500+
Ammonium bromide (50%)	NR	NR	.....	.....	450	500+	500+
Ammonium carbonate (saturated)	140	140	225	300	450	500+	500+
Ammonium chloride	140	140	225	300	450	500+	500+
Ammonium dichromate	NR	.....	125	250	450	.....	.....
Ammonium fluoride (25%)	140	140	200	300	450	.....	.....
Ammonium fluoride (saturated)	.....	.....	175	.....	450	.....	.....
Ammonium hydroxide (10%)	140	140	225	300	450	500+	500+
Ammonium hydroxide (conc)	NR	140	225	.....	450	500+	500+
Ammonium nitrate	140	140	150	300	450	500+	500+
Ammonium phosphate	140	.....	225	300	450	500+	500+
Ammonium sulfate	140	140	225	300	450	500+	500+
Amyl alcohol	104	140	75	300	450	.....	.....
Aniline	NR	NR	125	212	450	.....	.....
Aqua regia	70	NR	75	212	450	.....	.....
Arsenic acid	140	140	200	300	450	500+	500+
Barium carbonate	140	140	200	300	450	500+	500+
Barium chloride	140	140	200	300	450	500+	500+
Barium hydroxide	140	140	200	300	450	500+	500+
Barium sulfate	140	140	200	300	450	500+	500+
Barium sulfide	70	140	200	300	450	.....	.....
Benzaldehyde	NR	NR	75	121	450	500+	500+
Benzenesulfonic acid	140	140	75	121	450	500+	500+
Benzoic acid	140	140	150	250	450	500+	500+
Benzylamine	.....	.....	150	.....	450	.....	.....
Benzyl chloride	.....	.....	75	.....	450	.....	.....
Bismuth carbonate	140	140	225	300	450	.....	.....
Black liquor	140	.....	.....	300	450	500+	500+
Boric acid	140	140	225	300	450	500+	500+
Bromine (liquid)	NR	NR	NR	121	450	NR	NR

*** NOTE: The chemical resistance of PPL (Vue) Spra-Gard® Shields is consistent with the data for PPL Shields.**

RAMCO®

MAXIMUM TEMPERATURE (°F)
RAMCO® SAFETY SHIELDS

CORROSIVE STREAM	PVC	PE	PPL*	VUE	TFE	304	316
Bromine chloride	NR	.....	.....	.....	250	.....	.....
Butyl acetate	NR	68	NR	73	450	500+	500+
Butyl alcohol (butanol)	140	140	200	300	450	.....	.....
Butyl bromide	NR	NR	NR	.....	450	.....	.....
Butyl chloride	NR	NR	NR	.....	450	.....	.....
Butyric acid	73	NR	175	250	450	500+	500+
Calcium bisulfide	140	140	200	300	450	500+	500+
Calcium bisulfite	140	.....	200	300	450	500+	500+
Calcium carbonate	140	140	225	300	450	500+	500+
Calcium chlorate	140	140	200	300	450	500+	500+
Calcium chloride (saturated)	140	140	225	300	450	500+	500+
Calcium chlorite	140	140	150	.....	450	500+	500+
Calcium hydroxide (saturated)	140	140	225	300	450	500+	500+
Calcium hypochlorite	140	140	175	300	450	500+	500+
Calcium nitrate	140	140	200	300	450	.....	.....
Calcium oxide	140	140	225	300	450	.....	.....
Calcium sulfate	140	140	225	300	450	500+	500+
Carbon tetrachloride	NR	NR	NR	300	450	500+	500+
Chlorine dioxide	NR	NR	NR	212	450	NR	NR
Chromic acid (50%)	72	73	125	212	450	.....	500+
Chromic acid (100%)	NR	NR	NR	.....	450	.....	500+
Chromium trioxide (30%)	140	.....	125	.....	450	500+	500+
Copper carbonate (basic)	140	140	200	300	450	500+	500+
Copper chloride (saturated)	140	140	200	300	450	NR	NR
Copper cyanide (10%)	140	140	200	300	450	500+	500+
Copper fluoride	140	140	200	300	450	500+	500+
Copper nitrate	140	140	200	300	450	500+	500+
Copper sulfate (saturated)	140	140	200	300	450	500+	500+
Cresol	72	NR	NR	212	450	500+	500+
Cresylic acid (50%)	140	.....	NR	121	450	.....	500+

*** NOTE: The chemical resistance of PPL (Vue) Spra-Gard® Shields is consistent with the data for PPL Shields.**

RAMCO®

MAXIMUM TEMPERATURE (°F)
RAMCO® SAFETY SHIELDS

CORROSIVE STREAM	PVC	PE	PPL*	VUE	TFE	304	316
Cyclohexanone	NR	68	NR	121	450	500+	500+
Diethylamine	NR	NR	75	.....	450	.....	.....
Diethyl ether	NR	.....	NR	73	450	.....	.....
Diisobutyl ketone	NR	NR	75	121	450	500+	500+
Disodium phosphate	140	140	200	300	450	500+	500+
Ethyl acetate	NR	73	125	121	450	500+	500+
Ethyl alcohol (ethanol)	140	140	175	300	450	500+	500+
Ethyl chloride	NR	NR	NR	300	450	500+	500+
Ethylene dibromide	NR	NR	75	.....	450	500+	500+
Ethylene dichloride	NR	NR	75	73	450	500+	500+
Ethylene glycol	140	140	125	300	450	500+	500+
Ferric chloride	140	140	200	300	450	NR	NR
Ferric nitrate	140	140	200	300	450	500+	500+
Ferric sulfate	140	.....	200	300	450	500+	500+
Ferrous chloride	140	140	200	300	450	NR	NR
Ferrous nitrate	140	140	200	300	450	.....	.....
Fluosilicic acid	140	70	150	300	450	.....	.....
Formaldehyde (50%)	140	140	175	.....	450	500+	500+
Formic acid	70	140	125	250	450	500+	500+
Gasoline (petroleum)	.....	NR	NR	300	450	500+	500+
Glucose	140	140	225	300	450	500+	500+
Hydrobromic acid (10%)	140	140	225	300	450	.....	.....
Hydrobromic acid (50%)	140	140	175	300	450	NR	NR
Hydrochloric acid (10-20%)	140	140	200	300	450	500+	500+
Hydrochloric acid (35%)	140	140	200	300	450	.....	500+
Hydrofluoric acid (30%)	68	68	200	NR	NR	500+	500+
Hydrofluoric acid (50-60%)	68	68	200	NR	NR	500+	500+
Hydrofluoric acid (100%)	NR	NR	.....	NR	NR	.....	500+
Hydrogen peroxide (8-90%)	68	68	125	121	450	500+	500+
Hydrogen sulfide (aqueous)	140	140	175	121	450	500+	500+

*** NOTE: The chemical resistance of PPL (Vue) Spra-Gard® Shields is consistent with the data for PPL Shields.**

RAMCO®

MAXIMUM TEMPERATURE (°F)
RAMCO® SAFETY SHIELDS

CORROSIVE STREAM	PVC	PE	PPL*	VUE	TFE	304	316
Lactic acid (80%)	68	140	150	121	450	500+	500+
Lauryl chloride	72	.....	175	212	450	.....	.....
Magnesium carbonate	140	140	225	300	450	500+	500+
Magnesium chloride	140	140	225	300	450	500+	500+
Magnesium hydroxide	140	140	225	300	450	500+	500+
Magnesium nitrate	140	140	225	300	450	500+	500+
Magnesium sulfate (10%)	140	140	225	300	450	500+	500+
Magnesium sulfate (saturated)	.....	.....	225	300	450	500+	500+
Manganese sulfate (10%-saturated)	140	140	75	.....	450	.....	500+
Mercuric chloride	140	140	175	250	450	500+	500+
Mercuric nitrate	140	140	175	.....	450	500+	500+
Mercury	140	140	150	300	450	500+	500+
Methyl alcohol (methanol)	140	140	200	300	450	500+	500+
Methyl bromide	NR	NR	NR	300	450	.....	500+
Methyl chloride	NR	NR	NR	300	450	500+	500+
Methyl ethyl ketone	NR	NR	125	121	450	500+	500+
Methyl salicylate	NR	68	125	.....	450	500+	500+
Naphtha	140	NR	125	.....	450	500+	500+
Nickel chloride	140	140	200	300	450	500+	500+
Nitric acid (10%)	140	140	175	250	450	500+	500+
Nitric acid (30%)	140	140	150	212	450	500+	500+
Nitric acid (50%)	140	70	75	121	450	500+	500+
Nitric acid (70%)	73	NR	NR	121	450	500+	500+
Nitric acid (fuming)	NR	NR	NR	.....	450	500+	500+
Oleum	NR	NR	NR	73	450	500+	500+
Perchloric acid (10%)	104	140	150	212	450	500+	500+
Perchloric acid (70%)	NR	68	75	121	450	500+	500+
Phenol (5%)	72	70	200	121	450	500+	500+
Phenol (100%)	.....	.....	150	121	450	500+	500+
Phosgene (wet)	NR	.....	NR	.....	450	.....	.....

*** NOTE: The chemical resistance of PPL (Vue) Spra-Gard® Shields is consistent with the data for PPL Shields.**

RAMCO®

MAXIMUM TEMPERATURE (°F)
RAMCO® SAFETY SHIELDS

CORROSIVE STREAM	PVC	PE	PPL*	VUE	TFE	304	316
Phosphoric acid (10-50%)	140	140	225	300	450	500+	500+
Phosphoric acid (50-85%)	140	140	225	300	450	500+	500+
Phthalic acid	68	140	75	.....	450	500+	500+
Potassium aluminum chloride	140	.....	225	.....	450	.....	.....
Potassium aluminum sulfate (50%)	140	.....	225	300	450	.....	.....
Potassium bicarbonate	140	140	225	.....	450	500+	500+
Potassium borate	140	140	200	250	450	.....	.....
Potassium bromate	140	140	225	.....	450	.....	.....
Potassium bromide	140	140	225	300	450	500+	500+
Potassium carbonate	140	140	225	300	450	500+	500+
Potassium chlorate	140	140	225	300	450	500+	500+
Potassium chloride	140	140	200	300	450	500+	500+
Potassium chromate	140	140	225	300	450	.....	.....
Potassium cyanide	140	140	225	300	450	500+	500+
Potassium fluoride	140	140	175	.....	450	.....	.....
Potassium hydroxide (10%)	140	140	225	300	450	500+	500+
Potassium hydroxide (50%)	140	140	175	300	450	500+	500+
Potassium hydroxide (60-90%)	.....	.....	150	.....	450	500+	500+
Potassium hypochlorite	140	.....	175	.....	450	.....	.....
Potassium nitrate	140	140	175	300	450	500+	500+
Potassium sulfate	140	140	225	300	450	500+	500+
Potassium sulfide	104	140	175	.....	450	500+	500+
Propylene dibromide	.....	.....	75	.....	450	.....	.....
Propylene dichloride	NR	NR	75	.....	450	500+	500+
Sodium bromide	140	140	225	300	450	500+	500+
Sodium chlorate	140	140	200	300	450	500+	500+
Sodium chloride	140	140	225	300	450	500+	500+
Sodium chlorite	140	68	175	250	450	500+	500+
Sodium fluoride (saturated)	140	140	175	300	450	500+	500+
Sodium hydroxide (<10%)	140	140	200	300	450	500+	500+

*** NOTE: The chemical resistance of PPL (Vue) Spra-Gard® Shields is consistent with the data for PPL Shields.**

RAMCO®

MAXIMUM TEMPERATURE (°F)
RAMCO® SAFETY SHIELDS

CORROSIVE STREAM	PVC	PE	PPL*	VUE	TFE	304	316
Sodium hydroxide (10-50%)	140	140	200	250	450	500+	500+
Sodium hydroxide (>50%)	140	140	150	.....	450	.....	.....
Sodium hypochlorite	140	140	150	250	450	500+	500+
Sodium iodide	104	68	175	300	450	.....	.....
Sodium nitrate	140	140	175	300	450	500+	500+
Sodium nitrite	140	68	175	300	450	500+	500+
Sodium peroxide	140	.....	125	300	450	500+	500+
Sodium phosphate	140	140	175	300	450	500+	500+
Sodium silicate	140	140	225	300	450	500+	500+
Sodium sulfate	140	140	225	300	450	500+	500+
Sodium sulfide	104	140	150	300	450	500+	500+
Sodium sulfite	104	140	150	300	450	500+	500+
Stannic chloride	140	140	225	300	450	NR	NR
Sulfur chloride	140	.....	75	73	450	NR	NR
Sulfuric acid (10%)	140	140	225	212	450	500+	500+
Sulfuric acid (16%)	140	140	200	212	450	500+	500+
Sulfuric acid (30%)	140	140	200	212	450	500+	500+
Sulfuric acid (60%)	140	70	200	250	450	500+	500+
Sulfuric acid (85%)	NR	NR	175	250	450	500+	500+
Sulfuric acid (93-98%)	NR	NR	73	250	450	500+	500+
Sulfuric acid fuming (>98%)	NR	NR	NR	.....	450	500+	500+
Tannic acid	140	140	150	300	450	500+	500+
Titanium tetrachloride	NR	NR	NR	.....	450	500+	500+
Toluene	NR	NR	NR	73	450	500+	500+
Trichloroacetic (10%)	72	.....	1501	121	450	.....	.....
Trichloroacetic (100%)	68	.....	125	121	450	NR	NR
Urea	140	140	225	212	450	500+	500+
Zinc chloride	140	140	175	300	450	500+	500+
Zinc nitrate	140	.....	200	300	450	500+	500+
Zinc sulfate	140	140	200	300	450	500+	500+

*** NOTE: The chemical resistance of PPL (Vue) Spra-Gard® Shields is consistent with the data for PPL Shields.**

RAMCO®

SECTION

RAMCO®

THE CHEMICAL ELEMENTS

NAME	SYMBOL	ATOMIC NUMBER	ATOMIC WEIGHT	NAME	SYMBOL	ATOMIC NUMBER	ATOMIC WEIGHT
Actinium	Ac	89	227.028	Nitrogen	N	7	14.0067
Aluminum	Al	13	26.9815	Nobelium	No	102	259
Americum	Am	95	243	Osmium	Os	76	190.2
Antimony	Sb	51	121.75	Oxygen	O	8	15.9994
Argon	Ar	18	39.948	Palladium	Pd	46	106.42
Arsenic	As	33	74.9216	Phosphorus	P	15	30.9738
Astatine	At	85	210	Platinum	Pt	78	195.08
Barium	Ba	56	137.327	Plutonium	Pu	94	244
Berkelium	Bk	97	247	Polonium	Po	84	209
Beryllium	Be	4	9.01218	Potassium	K	19	39.0983
Bismuth	Bi	83	208.980	Praseodymium	Pr	59	140.908
Boron	B	5	10.811	Promethium	Pm	61	145
Bromine	Br	35	79.904	Protoactinium	Pa	91	231.014
Cadmium	Cd	48	112.411	Radium	Ra	88	226.025
Caesium	Cs	55	132.905	Radon	Rn	86	222
Calcium	Ca	20	40.078	Rhenium	Re	75	186.207
Californium	Cf	98	251	Rhodium	Rh	45	102.901
Carbon	C	6	12.011	Rudbidium	Rb	37	85.4678
Cerium	Ce	58	140.115	Ruthenium	Ru	44	101.07
Cesium	Cs	55	132.905	Samarium	Sm	62	150.36
Chlorine	Cl	17	35.4527	Scandium	Sc	21	44.9559
Chromium	Cr	24	51.9961	Selenium	Se	34	78.96
Cobalt	Co	27	58.93320	Silicon	Si	14	28.0855
Copper	Cu	29	63.546	Silver	Ag	47	107.868
Curium	Cm	96	247	Sodium	Na	11	22.9898
Dysprosium	Dy	66	162.50	Strontium	Sr	38	87.62
Einsteinium	Es	99	252	Sulfur	S	16	32.066
Erbium	Er	68	167.26	Tantalum	Ta	73	180.9479
Europium	Eu	63	151.965	Technetium	Tc	43	98
Fermium	Fm	100	257	Tellurium	Te	52	127.60
Fluorine	F	9	18.9984	Terbium	Tb	65	158.925
Francium	Fr	87	223	Thallium	Tl	81	204.383
Gadolinium	Gd	64	157.25	Thorium	Th	90	232.038
Gallium	Ga	31	69.723	Thullium	Tm	69	168.934
Germanium	Ge	32	72.61	Tin	Sn	50	118.710
Gold	Au	79	196.967	Titanium	Ti	22	47.88
Hafnium	Hf	72	178.49	Tungesten	W	74	183.85
Helium	He	2	4.00260	Unnihexium	Unh	106	263
Holmium	Ho	67	164.930	Unnilpentium	Unp	105	262
Hydrogen	H	1	1.00794	Unnilquadium	Unq	104	261
Indium	In	49	114.82	Unnilseptium	Uns	107	262
Iodine	I	53	126.904	Uranium	U	92	238.029
Iridium	Ir	77	192.22	Vanadium	V	23	50.9415
Iron	Fe	26	55.847	Wolfram			
Krypton	Kr	36	83.80	(see Tugsten)			
Lanthanum	La	57	138.906	Xenon	Xe	54	131.29
Lawrencium	Lr	103	260	Ytterbium	Yb	70	173.04
Lead	Pb	82	207.2	Yttrium	Y	39	88.9059
Lithium	Li	3	6.941	Zinc	Zn	30	65.39
Lutetium	Lu	71	174.967	Zirconium	Zr	40	91.224
Magnesium	Mg	12	24.3050				
Manganese	Mn	25	54.9381				
Mandelevium	Md	101	258				
Mercury	Hg	80	200.59				
Molybdenum	Mo	42	95.94				
Neodymium	Nd	60	144.24				
Neon	Ne	10	20.1797				
Neptumium	Np	93	237.048				
Nickel	Ni	28	58.69				
Niobium	Nb	41	92.9064				

RAMCO®

TEMPERATURE CONVERSION

Fahrenheit to Celsius **Celsius to Fahrenheit**

Formula: C.to F.= (°C. x 9/5) + 32 = °F.
F. to C.= (°F. - 32) x 5/9 = °C.

The table below can be used to convert °C. to °F. and vice versa. Locate the temperature to be converted in the center column (bold face). The number to the left gives corresponding °C. and to the right the corresponding °F.

READING IN F OR C °C. TO BE °F. CONVERTED			READING IN F OR C °C. TO BE °F. CONVERTED			READING IN F OR C °C. TO BE °F. CONVERTED			READING IN F OR C °C. TO BE °F. CONVERTED			READING IN F OR C °C. TO BE °F. CONVERTED			READING IN F OR C °C. TO BE °F. CONVERTED		
-128.9	-200	-328.0	- 11.7	11	51.8	0.6	31	87.8	10.6	51	123.8	21.7	71	159.8	32.8	91	195.8
- 73.3	-100	-148.0	- 11.1	12	53.6	0.0	32	89.6	11.1	52	125.6	22.2	72	161.6	33.3	92	197.6
- 62.2	- 80	-112.0	- 10.6	13	55.4	0.6	33	91.4	11.7	53	127.4	22.8	73	163.4	33.9	93	199.4
- 51.1	- 60	- 76.0	- 10.0	14	57.2	1.1	34	93.2	12.2	54	129.2	23.3	74	165.2	34.4	94	201.2
- 45.6	- 50	- 58.0	- 9.4	15	59.0	1.7	35	95.0	12.8	55	131.0	23.9	75	167.0	35.0	95	203.0
- 40.0	- 40	- 40.0	- 8.9	16	60.8	2.2	36	96.8	13.3	56	132.8	24.4	76	168.8	35.6	96	204.8
- 34.4	- 30	- 22.0	- 8.3	17	62.6	2.8	37	98.6	13.9	57	134.6	25.0	77	170.6	36.1	97	206.6
- 28.9	- 20	- 4.0	- 7.8	18	64.4	3.3	38	100.4	14.4	58	136.4	25.6	78	172.4	36.7	98	208.4
- 23.3	- 10	14.0	- 7.2	19	66.2	3.9	39	102.2	15.0	59	138.2	26.1	79	174.2	37.2	99	210.2
- 17.8	0	32.0	- 6.7	20	68.0	4.4	40	104.0	15.6	60	140.0	26.7	80	176.0	37.8	100	212.0
- 17.2	1	33.8	- 6.1	21	69.8	5.0	41	105.8	16.1	61	141.8	27.2	81	177.8	48.9	120	248.0
- 16.7	2	35.6	- 5.6	22	71.6	5.6	42	107.6	16.7	62	143.6	27.8	82	179.6	60.0	140	284.0
- 16.1	3	37.4	- 5.0	23	73.4	6.1	43	109.4	17.2	63	145.4	28.3	83	181.4	71.1	160	320.0
- 15.6	4	39.2	- 4.4	24	75.2	6.7	44	111.2	17.8	64	147.2	28.9	84	183.2	93.3	200	392.0
- 15.0	5	41.0	- 3.9	25	77.0	7.2	45	113.0	18.3	65	149.0	29.4	85	185.0	100.0	212	413.6
- 14.4	6	42.8	- 3.3	26	78.8	7.8	46	114.8	18.9	66	150.8	30.0	86	186.8	115.6	240	464.0
- 13.9	7	44.6	- 2.8	27	80.6	8.3	47	116.6	19.4	67	152.6	30.6	87	188.6	137.8	280	536.0
- 13.3	8	46.4	- 2.2	28	82.4	8.9	48	118.4	20.0	68	154.4	31.1	88	190.4	160.0	320	608.0
- 12.8	9	48.2	- 1.7	29	84.2	9.4	49	120.2	20.6	69	156.2	31.7	89	192.2	182.2	360	680.0
- 12.2	10	50.0	- 1.1	30	86.0	10.0	50	122.0	21.1	70	158.0	32.2	90	194.0	204.4	400	752.0

METRIC CONVERSION TABLE

Inches	Milimeters	Inches	Milimeters	Inches	Milimeters	Inches	Milimeters	Inches	Milimeters	Inches	Milimeters
1/16	1.5875	2-1/16	52.3876	4-1/16	103.188	6-1/16	153.988	8-1/16	204.788	10-1/16	255.588
1/8	3.1750	2-1/8	53.9751	4-1/8	104.775	6-1/8	155.575	8-1/8	206.375	10-1/8	257.176
3/16	4.7625	2-3/16	55.5626	4-3/16	106.363	6-3/16	157.163	8-3/16	207.963	10-3/16	258.763
1/4	6.3500	2-1/4	57.1501	4-1/4	107.950	6-1/4	158.750	8-1/4	209.550	10-1/4	260.351
5/16	7.9375	2-5/16	58.7376	4-5/16	109.538	6-5/16	160.338	8-5/16	211.138	10-5/16	261.938
3/8	9.5250	2-3/8	60.3251	4-3/8	111.125	6-3/8	161.925	8-3/8	212.725	10-3/8	263.526
7/16	11.1125	2-7/16	61.9126	4-7/16	112.713	6-7/16	163.513	8-7/16	214.313	10-7/16	265.113
1/2	12.7000	2-1/2	63.5001	4-1/2	114.300	6-1/2	165.100	8-1/2	215.900	10-1/2	266.701
9/16	14.2875	2-9/16	65.0876	4-9/16	115.888	6-9/16	166.688	8-9/16	217.488	10-9/16	268.288
5/8	15.8750	2-5/8	66.6751	4-5/8	117.475	6-5/8	168.275	8-5/8	219.075	10-5/8	269.876
11/16	17.4625	2-11/16	68.2626	4-11/16	119.063	6-11/16	169.863	8-11/16	220.663	10-11/16	271.463
3/4	19.0500	2-3/4	69.8501	4-3/4	120.650	6-3/4	171.450	8-3/4	222.250	10-3/4	273.051
13/16	20.6375	2-13/16	71.4376	4-13/16	122.238	6-13/16	173.038	8-13/16	223.838	10-13/16	274.638
7/8	22.2250	2-7/8	73.0251	4-7/8	123.825	6-7/8	174.625	8-7/8	225.425	10-7/8	276.226
15/16	23.8125	2-15/16	74.6126	4-15/16	125.413	6-15/16	176.213	8-15/16	227.013	10-15/16	277.813
1	25.4001	3	76.2002	5	127.000	7	177.800	9	228.600	11	279.401
1-1/16	26.9876	3-1/16	77.7877	5-1/16	128.588	7-1/16	179.388	9-1/16	230.188	11-1/16	280.988
1-1/8	28.5751	3-1/8	79.3752	5-1/8	130.175	7-1/8	180.975	9-1/8	231.775	11-1/8	282.576
1-3/16	30.1626	3-3/16	80.9627	5-3/16	131.763	7-3/16	182.563	9-3/16	233.363	11-3/16	284.163
1-1/4	31.7501	3-1/4	82.5502	5-1/4	133.350	7-1/4	184.150	9-1/4	234.950	11-1/4	285.751
1-5/16	33.3376	3-5/16	84.1377	5-5/16	134.938	7-5/16	185.738	9-5/16	236.538	11-5/16	287.338
1-3/8	34.9251	3-3/8	85.7252	5-3/8	136.525	7-3/8	187.325	9-3/8	238.125	11-3/8	288.926
1-7/16	36.5126	3-7/16	87.3127	5-7/16	138.113	7-7/16	188.913	9-7/16	239.713	11-7/16	290.513
1-1/2	38.1001	3-1/2	88.9002	5-1/2	139.700	7-1/2	190.500	9-1/2	241.300	11-1/2	292.101
1-9/16	39.6876	3-9/16	90.4877	5-9/16	141.288	7-9/16	192.088	9-9/16	242.888	11-9/16	293.688
1-5/8	41.2751	3-5/8	92.0752	5-5/8	142.875	7-5/8	193.675	9-5/8	244.475	11-5/8	295.276
1-11/16	42.8626	3-11/16	93.6627	5-11/16	144.463	7-11/16	195.263	9-11/16	246.063	11-11/16	296.863
1-3/4	44.4501	3-3/4	95.2502	5-3/4	146.051	7-3/4	196.850	9-3/4	247.650	11-3/4	298.451
1-13/16	46.0376	3-13/16	96.8377	5-13/16	147.638	7-13/16	198.438	9-13/16	249.238	11-13/16	300.038
1-7/8	47.6251	3-7/8	98.4252	5-7/8	149.225	7-7/8	200.025	9-7/8	250.825	11-7/8	301.626
1-15/16	49.2126	3-15/16	100.013	5-15/16	150.813	7-15/16	201.613	9-15/16	252.413	11-15/16	303.213
2	50.8001	4	101.600	6	152.400	8	203.200	10	254.001	12	304.801

RAMCO®

CONVERSION FACTORS

TO CONVERT FROM	TO	MULTIPLY BY
A		
Abampere	Ampere	10
Abcoulomb	Coulomb	10
Abfarad	Farad	1×10^{9}
Abhenry	Henry	1×10^{9}
Abmho	Siemens (mho)	1×10^{9}
Abohm	Ohm	1×10^{9}
Abvolt	Volt	1×10^{8}
Acre	Hectare	0.40468564
	Square foot	43560
	Square kilometer	4.046856×10^{3}
	Square meter	4046.85642
	Square mile	1.5625×10^{3}
	Square yard	4840
Acre (U.S.Survey)	Square meter	4046.872610
Acre-foot	Cubic meter	1233.482
	Cubic yard	1613.333
Acre-inch	Cubic foot	3630
	Cubic meter	102.7902
	Gallon (Brit.)	22610.67
	Gallon (U.S.)	27154.29
Ampere (int. mean)	Ampere	0.99985
Ampere (int. U.S.)	Ampere	0.999835
Ampere/square centimeter	Ampere/square inch	6.4516
Ampere/square inch	Ampere/square centimeter	0.1550003
Ampere-hour	Coulomb	3600
Ampere(-turn)	Gilbert	1.256637
Angstrom	Nanometer	0.1
Are	Square foot	1076.391
	Square meter	100
Astronomical unit	Kilometer	1.4959787×10^{8}
Atmosphere	Atmosphere (tech.)	1.033227
	Bar	1.01325
	Foot of H_2O (conv.)	33.89854
	Inch of Hg (conv.)	29.92126
	Kilogram-force/square centimeter	1.033227
	Kilopascal	101.325
	Meter of H_2O (conv.)	10.33227
	Millibar	1013.25
	Millimeter of Hg (conv.)	760
	Newton/square centimeter	10.1325
	Pascal (N/square meter)	1.01325×10^{5}
	Pound-force/square foot	2116.22
	Pound-force/square inch	14.69595
	Ton-force (long)/square foot	0.944740
	Ton-force (short)/square foot	1.058108
	Ton-force (long)/square inch	6.56069×10^{3}
	Ton-force (short)/square inch	7.34797×10^{3}
	Torr	760
Atmosphere (tech.)	Atmosphere	0.967841
	Bar	0.980665
	Foot of H_2O (conv.)	32.8084
	Inch of Hg (conv.)	28.9590
	Kilogram-force/square centimeter	1
	Kilopascal	98.0665
	Meter of H_2O (conv.)	10
	Millibar	980.665
	Millimeter of Hg (conv.)	735.559
	Newton/square centimeter	9.80665
	Pascal (N/m²)	98066.5
	Pound-force/square inch	14.22334
B		
Bag (Brit.)	Gallon (Brit.)	24
Bar	Atmosphere	0.9869233
	Atmosphere (tech.)	1.019716
	Dyne/square centimeter	1×10^{6}
	Foot of H_2O (conv.)	33.4553
	Inch of Hg (conv.)	29.5300
	Kilogram-force/square centimeter	1.019716
	Kilopascal	100
	Meter of H_2O (conv.)	10.19716
	Millibar	1000
	Millimeter of Hg (conv.)	750.062
	Newton/square centimeter	10
	Pascal (N/m²)	1×10^{5}
	Pound-force/square foot	2088.54
	Pound-force/square inch	14.50377
	Ton-force (long)/square foot	0.932385
	Ton-force (short)/square foot	1.04427
	Ton-force (long)/square inch	6.47490×10^{3}
	Ton-force (short)/square inch	7.25189×10^{3}
	Torr	750.062
Barleycorn (Brit.)	Inch	0.333333 (1/3)
Barn	Square meter	1×10^{28}
Barrel (Brit. beer)	Gallon (Brit.)	36
	Liter	163.6592
Barrel (Brit. wine)	Gallon (Brit.)	31.5
	Liter	143.2018
Barrel (petroleum)	Cubic foot	5.614583
	Cubic meter	0.1589873
	Gallon (Brit.)	34.97232
	Gallon (U.S)	42
	Liter	158.9873
Barrel (U.S., dry)	Bushel (U.S.)	3.281219
	Cubic foot	4.083333
	Cubic inch	7056
	Cubic meter	0.1156271
	Liter	115.6271
	Pint (U.S., dry)	209.998
	Quart (U.S., dry)	104.9990
Barrel (U.S., cranb.)	Cubic inch	5826
	Liter	95.4710
Barrel (U.S., liquid)	Cubic foot	4.2109375
	Cubic inch	7276.5
	Cubic meter	0.1192405
	Gallon (Brit.)	26.22925
	Gallon (U.S.)	31.5
	Liter	119.2405
Barye	Bar	1×10^{6}
	Dyne/square centimeter	1
Becquerel	Curie	2.702703×10^{11}
Biot	Ampere	10
Board foot	Cubic foot	0.083333 (1/12)
Bolt (cloth)	Foot	120
Btu	Calorie	251.996
	Cubic foot-atmosphere	0.367717
	Foot-poundal	25036.9
	Foot-pound-force	778.169
	Horsepower-hour	3.93015×10^{4}
	Horsepower-hour (metric)	3.98466×10^{4}
	Joule	1055.056
	Kilocalorie	0.251996
	Kilogram-force-meter	107.586
	Kilowatt-hour	2.93071×10^{4}
	Liter-atmosphere	10.4126
	Watt-hour	0.293071
Btu (39°F, 4°C)	Joule	1059.67
Btu (60°F, 15.6°C)	Joule	1054.68
Btu (mean)	Joule	1055.87
Btu (thermochemical)	Joule	1054.35
Btu/cubic foot	Joule/cubic meter	37258.9
	Kilocalorie/cubic meter	8.89915
Btu/°F	Calorie/°C	453.592
	Joule/°C	1899.10
Btu/hour	Btu/minute	0.0166667 (1/60)
	Btu/second	2.77778×10^{4}
	Calorie/second	0.0699988
	Foot-pound-force/second	0.216158
	Horsepower	3.93015×10^{4}

TO CONVERT FROM	TO	MULTIPLY BY
	Watt	0.293071
Btu/(hour x square foot)	Watt/square meter	3.15459
Btu/(hour x square foot x °F)	Calorie/(second x square meter x °C)	1.35623
	Watt/(square meter x °C)	5.67826
Btu/(hour x square foot x °F/foot)	Watt/(meter x °C)	1.73073
Btu/(hour x square foot x °F/inch)	Watt/(meter x °C)	0.144228
Btu/minute	Calorie/second	4.19993
	Horsepower	0.0235809
	Watt	17.5843
Btu/(minute x square foot)	Watt/square meter	189.273
Btu/pound	Calorie/gram	0.555556
	Joule/kilogram	2326
	Kilocalorie/kilogram	0.555556
	Watt-hour/kilogram	0.646111
Btu/(pound x °F)	Calorie/(gram x °C)	1
	Joule/(kilogram x °C)	4186.8
Btu/second	Horsepower	1.41485
	Kilowatt	1.055056
Btu/(second x square foot)	Kilowatt/square meter	11.3565
Btu/(second x square foot x °F)	Kilowatt/(square meter x °C)	20.4417
Btu/(second x square foot x °F/foot)	Kilowatt/(meter x °C)	6.23064
Btu/(second x square foot x °F/inch)	Watt/(meter x °C)	519.220
Btu/square foot	Joule/square meter	11356.5
	Watt-hour/square meter	3.15459
Bucket (Brit.)	Gallon (Brit.)	4
Bushel (Brit.)	Bushel (U.S.)	1.032057
	Gallon (Brit.)	8
	Liter	36.36872
Bushel (U.S.)	Barrel (U.S., dry)	0.3047647
	Bushel (Brit.)	0.9689390
	Cubic foot	1.244456
	Cubic inch	2150.42
	Gallon (Brit.)	7.751512
	Gallon (U.S. ,liquid)	9.309177
	Liter	35.23907
	Peck (U.S.)	4
	Pint (U.S., dry)	64
	Quart (U.S., dry)	32
Butt (Brit.)	Gallon (Brit.)	108 or 126

C

Cable length (int.)	Foot	607.6115
	Meter	185.2
	Mile (nautical)	0.1
Cable length (U.S.)	Foot	720
	Meter	219.456
	Mile (nautical)	0.1184968
	Mile (statute)	0.1363636
Caliber	Inch	0.01
	Millimeter	0.254
Calorie	Btu	3.96832×10^{-3}
	Cubic foot-atmosphere	1.45922×10^{-3}
	Foot-poundal	99.3543
	Foot-pound-force	3.08803
	Horsepower-hour	1.55961×10^{-6}
	Horsepower-hour (metric)	1.58124×10^{-6}
	Joule	4.1868
	Kilocalorie	0.001
	Kilogram-force-meter	0.426935
	Kilowatt-hour	1.163×10^{-6}
	Liter-atmosphere	0.0413205
	Watt-hour	1.163×10^{-3}
Calorie (15°C)	Joule	4.1855
Calorie (20°C)	Joule	4.18190
Calorie (mean)	Joule	4.19002
Calorie (thermochem.)	Joule	4.184
Calorie/°C	Btu/°F	2.20462×10^{-3}
	Joule/°F	2.326
Calorie/gram	Btu/pound	1.8
	Joule/kilogram	4186.8
Calorie/(gram x °C)	Btu/(pound x °F)	1
	Joule/(kilogram x °C)	4186.8
Calorie/minute	Watt	0.06978
Calorie/(minute x square centimeter)	Watt/square meter	697.8
Calorie/second	Watt	4.1868
Calorie/(second x square centimeter)	Kilowatt/square meter	41.868
Calorie/(second x square centimeter x °C)	Kilowatt/(square meter x °C)	41.868
Calorie/(second x square centimeter x °C/centimeter)	Watt/(meter x °C)	418.68
Calorie/square centimeter	Kilojoule/square meter	41.868
Candela	Hefner unit	1.11
	Lumen/steradian	1
Candela/square centimeter	Candela/square foot	929.0304
	Candela/square inch	6.4516
Candela/square foot	Candela/square inch	6.944444×10^{-3}
	Candela/square meter	10.76391
	Lambert	3.381582×10^{-3}
Candela/square inch	Candela/ square centimeter	0.1550003
	Candela/square foot	144
	Foot-lambert	452.3893
	Lambert	0.4869478
Candela/square meter	Candela/square foot	0.09290304
	Lambert	3.141593×10^{-4}
Carat (metric)	Gram	0.2
Cental	Kilogram	45.359237
	Pound	100
°C heat unit (chu)	Btu	1.8
	Calorie	453.592
	Joule	1899.10
Centiliter	Cubic centimeter	10
	Cubic inch	0.6102374
	Drachm (Brit., fluid)	2.815606
	Dram (U.S., fluid)	2.705122
	Ounce (Brit., fluid)	0.3519508
	Ounce (U.S., fluid)	0.3381402
Centimeter	Foot	0.03280840
	Inch	0.3937008
	Micrometer	10000
	Mil	393.7008
	Millimeter	10
	Yard	0.01093613
Centimeter of Hg (conv.)	Atmosphere	0.0131579
	Millibar	13.3322
	Millimeter of H_2O (conv.)	135.951
	Pascal	1333.22
	Pound-force/square inch	0.193368
Centimeter of H_2O (conv.)	Atmosphere	9.67841×10^{-4}
	Millibar	0.980665
	Millimeter of Hg (conv.)	0.735559
	Kilogram force/square centimeter	0.001
	Pascal	98.0665
	Pound-force/square inch	0.0142233
Centimeter/second	Foot/minute	1.968504
	Foot/second	0.03280840
	Kilometer/hour	0.036
	Meter/minute	0.6
	Mile/hour	0.02236936
Centimeter/square second	Foot/square second	0.03280840
	Kilometer/(hour x second)	0.036
	Meter/square second	0.01
	Mile/(hour x second)	0.02236936
Centipoise	Pascal-second	0.001
Centistokes	Square meter/second	1×10^{-6}
Chain (Gunter's)	Foot	66
Chain (Ramsden's)	Foot	100
Circular inch	Circular mil	1×10^{6}
	Square centimeter	5.067075
	Square inch	0.7853982
Circular mil	Square inch	7.853982×10^{-7}
	Square micrometer	506.7075
	Square mil	0.7853982
Circular millimeter	Square millimeter	0.7853982
Circumference	Degree	360
	Gon (grade)	400
Clo	(°C x square meter)/watt	0.155
Cord	Cord-foot	8
	Cubic foot	128
Cord-foot	Cord	0.125 (1/8)
	Cubic foot	16
Coulomb	Ampere-second	1

RAMCO®

TO CONVERT FROM	TO	MULTIPLY BY
Cubic centimeter	Cubic foot	3.531467×10^{-5}
	Cubic inch	0.06102374
	Cubic meter	1×10^{-6}
	Cubic millimeter	1000
	Cubic yard	1.307951×10^{-6}
	Drachm (Brit., fluid)	0.2815606
	Dram (U.S., fluid)	0.2705122
	Gallon (Brit.)	2.199692×10^{-4}
	Gallon (U.S.)	2.641721×10^{-4}
	Gill (Brit.)	7.039016×10^{-3}
	Gill (U.S.)	8.453506×10^{-3}
	Liter	0.001
	Milliliter	1
	Minim (Brit.)	16.89364
	Minim (U.S.)	16.23073
	Ounce (Brit., fluid)	0.03519508
	Ounce (U.S., fluid)	0.03381402
	Pint (Brit.)	1.759754×10^{-3}
	Pint (U.S., dry)	1.816166×10^{-3}
	Pint (U.S., liquid)	2.113376×10^{-3}
	Quart (Brit.)	8.798770×10^{-4}
	Quart (U.S., dry)	9.080830×10^{-4}
	Quart (U.S., liquid)	1.056688×10^{-3}
Cubic centimeter/gram	Cubic foot/pound	0.0160185
Cubic centimeter/second	Cubic foot/minute	2.118880×10^{-3}
	Liter/hour	3.6
Cubic centimeter-atmosphere	Joule	0.101325
	Watt-hour	2.814583×10^{-5}
Cubic decimeter	Cubic centimeter	1000
	Cubic foot	0.03531467
	Cubic inch	61.02374
	Cubic meter	0.001
	Liter	1
Cubic foot	Acre-foot	2.295684×10^{-5}
	Board foot	12
	Bushel (Brit.)	0.7786044
	Bushel (U.S.)	0.8035640
	Cord	7.8125×10^{-3} (1/128)
	Cord-foot	0.0625 (1/16)
	Cubic centimeter	28316.847
	Cubic inch	1728
	Cubic meter	0.028316847
	Cubic yard	0.03703704 (1/27)
	Gallon (Brit.)	6.228835
	Gallon (U.S.)	7.480519
	Liter	28.316847
	Pint (Brit.)	49.83068
	Pint (U.S., dry)	51.42809
	Pint (U.S., liquid)	59.84416
	Quart (Brit.)	24.91534
	Quart (U.S., dry)	25.71405
	Quart (U.S., liquid)	29.92208
Cubic foot-hour	Cubic centimeter/second	7.865791
	Liter/minute	0.4719474
Cubic foot/minute	Cubic centimeter/second	471.9474
	Gallon (Brit.)/second	0.1038139
	Gallon (U.S.)/second	0.1246753
Cubic foot/pound	Cubic meter/kilogram	0.06242796
Cubic foot/second	Cubic meter/hour	101.9406
	Cubic yard/minute	2.222222
	Gallon (Brit.)/minute	373.7301
	Gallon (U.S.)/minute	448.8312
	Liter/minute	1699.011
Cubic foot-atmosphere	Btu	2.71948
	Calorie	685.298
	Foot-pound-force	2116.22
	Joule	2869.205
	Kilogram-force-meter	292.577
	Liter-atmosphere	28.31685
	Watt-hour	0.7970012
Cubic foot (pound-force square inch)	Btu	0.185050
	Calorie	46.6317
	Joule	195.238
	Watt-hour	0.0542327
Cubic inch	Board foot	6.944444×10^{-3}
	Bushel (Brit.)	4.505813×10^{-4}
	Bushel (U.S.)	4.650254×10^{-4}
	Cubic centimeter	16.387064
	Cubic foot	5.787037×10^{-4}
	Cubic meter	1.6387064×10^{-5}
	Cubic yard	2.143347×10^{-5}
	Drachm (Brit., fluid)	4.613952
	Dram (U.S., fluid)	4.432900
	Gallon (Brit.)	3.604650×10^{-3}
	Gallon (U.S.)	4.329004×10^{-3}
	Liter	0.016387064
	Millimeter	16.387064
	Ounce (Brit., fluid)	0.5767440
	Ounce (U.S., fluid)	0.5541126
	Pint (Brit.)	0.02883720
	Pint (U.S., dry)	0.02976163
	Pint (U.S., liquid)	0.03463203
	Quart (Brit.)	0.01441860
	Quart (U.S., dry)	0.01488081
	Quart (U.S., liquid)	0.01731602
Cubic inch/minute	Cubic centimeter/second	0.2731177
Cubic kilometer	Cubic mile	0.2399128
Cubic meter	Barrel (petroleum)	6.289811
	Barrel (U.S., dry)	8.648490
	Barrel (U.S., liquid)	8.386414
	Bushel (U.S.)	28.37759
	Cubic centimeter	1×10^{6}
	Cubic decimeter	1000
	Cubic foot	35.31467
	Cubic inch	61023.74
	Cubic yard	1.307951
	Gallon (Brit.)	219.9692
	Gallon (U.S.)	264.1721
	Liter	1000
	Pint (Brit.)	1759.754
	Pint (U.S., dry)	1816.166
	Pint (U.S., liquid)	2113.376
	Quart (Brit.)	879.8770
	Quart (U.S., dry)	908.0830
	Quart (U.S., liquid)	1056.688
	Register ton	0.3531467
Cubic meter/kilogram	Cubic foot/pound	16.01846
Cubic mile	Cubic kilometer	4.168182
Cubic millimeter	Cubic centimeter	0.001
	Cubic inch	6.102374×10^{-5}
	Minim (Brit.)	0.01689364
	Minim (U.S.)	0.01623073
Cubic yard	Bushel (Brit.)	21.02232
	Bushel (U.S.)	21.69623
	Cubic foot	27
	Cubic inch	46656
	Cubic meter	0.76455486
	Gallon (Brit.)	168.1786
	Gallon (U.S.)	201.9740
	Liter	764.5549
Cubic yard/minute	Cubic foot/second	0.45
	Gallon (Brit.)/second	2.802976
	Gallon (U.S.)/second	3.366234
	Liter/second	12.74258
Cubit	Inch	18
Cup (metric)	Milliliter	200
Cup (U.S.)	Milliliter	236.588
	Ounce (U.S., fluid)	8
Curie	Becquerel	3.7×10^{10}

D

Darcy	Square meter	9.869233×10^{-13}
Day (mean solar)	Hour	24
	Minute	1440
	Second	86400
Day (sidereal)	Second	86164.09
Decibel	Neper	0.115129255
Degree (angular)	Circumference	2.777778×10^{-3}
	Gon (grade)	1.111111
	Minute (angular)	60
	Quadrant	0.01111111 (1/90)
	Radian	0.01745329
	Second (angular)	3600
Degree/foot	Radian/meter	0.05726146
Degree/inch	Radian/meter	0.6871375
Degree/second	Revolution/minute	0.1666667 (1/6)
°C (temp. interval)	°Fahrenheit	1.8
	°Rankine	1.8
	Kelvin	1
(°C x hour)/kilocalorie	°C/watt	0.859845

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TO CONVERT FROM	TO	MULTIPLY BY
(°C x hour x square meter)/kilocalorie	(°C x square meter)/watt	0.859845
°F (temp. interval)	°Celsius	0.5555556 (5/9)
	°Rankine	1
	Kelvin	0.5555556 (5/9)
(°F x hour)/Btu	°C/watt	1.89563
(°F x hour x square foot)/Btu	(°C x square meter)/watt	0.176110
(°F/inch x hour x square foot)/Btu	(°C x meter)/watt	6.93347
Denier	Tex	0.111111 (1/9)
Drachm (Brit., fluid)	Drachm (U.S., fluid)	0.9607599
	Milliliter	3.551633
	Minim (Brit.)	60
	Ounce (Brit., fluid)	0.125 (1/8)
Dram (apoth. or troy)	Dram (avoirdupois)	2.1942857
	Grain	60
	Gram	3.8879346
	Ounce (apoth. or troy)	0.125 (1/8)
	Pennyweight	2.5
	Scruple	3
Dram (avoirdupois)	Grain	27.34375
	Gram	1.7718452
	Ounce (avoirdupois)	0.0625 (1/16)
Dram (U.S., fluid)	Cubic centimeter	3.696691
	Cubic inch	0.2255859
	Drachm (Brit., fluid)	1.040843
	Gallon (U.S.)	9.765625×10^{-4}
	Gill (U.S.)	0.03125 (1/32)
	Milliliter	3.696691
	Minim (U.S.)	60
	Ounce (U.S., fluid)	0.125 (1/8)
	Pint (U.S., liquid)	7.8125×10^{-3} (1/128)
	Quart (U.S., liquid)	3.90625×10^{-3}
Dyne	Kilogram-force	1.019716×10^{-6}
	Newton	1×10^{-5}
	Poundal	7.233014×10^{-5}
	Pound-force	2.248089×10^{-6}
Dyne/centimeter	Newton/meter	0.001
Dyne/square centimeter	Bar	1×10^{-6}
	Kilogram-force/square centimeter	1.019716×10^{-6}
	Millimeter of H_2O (conv.)	0.01019716
	Pascal (N/square meter)	0.1
	Pound-force/square inch	1.450377×10^{-5}
Dyne-centimeter	Erg	1
	Foot-poundal	2.37304×10^{-6}
	Foot-pound-force	7.37562×10^{-8}
	Joule	1×10^{-7}
	Kilogram-force-meter	1.019716×10^{-8}
	Newton-meter	1×10^{-7}
Dyne-second/square centimeter	Poise	1
	Pascal-second	0.1

E

Electronvolt	Erg	1.60219×10^{-12}
	Joule	1.60219×10^{-19}
Ell	Inch	45
Erg	Dyne-centimeter	1
	Joule	1×10^{-7}
	Watt-hour	2.777778×10^{-11}
Erg/(square centimeter x second)	Watt/square meter	0.001

F

Farad (int. mean)	Farad	0.999510
Farad (int. U.S.)	Farad	0.999505
Fathom	Foot	6
Fermi	Meter	1×10^{-15}
Firkin (Brit.)	Gallon (Brit.)	9
Firkin (U.S.)	Gallon (U.S.)	9
Foot	Centimeter	30.48
	Foot (U.S. Survey)	0.999998
	Inch	12
	Meter	0.3048
	Millimeter	304.8
	Mile (nautical)	1.645788×10^{-4}
	Mile (statute)	1.893939×10^{-4}
	Yard	0.333333 (1/3)
Foot (U.S. Survey)	Foot	1.000002
	Meter	0.30480060960
Foot of H_2O (conv.)	Atmosphere	0.0294998
	Bar	0.0298907
	Inch of Hg (conv.)	0.882671
	Kilogram-force/square centimeter	0.03048
	Millimeter of Hg (conv.)	22.4198
	Pascal (N/square meter)	2989.07
	Pound-force/square inch	0.433527
Foot/°F	Meter/°C	0.54864
Foot/hour	Meter/second	8.466667×10^{-5}
Foot/minute	Kilometer/hour	0.018288
	Knot	9.87473×10^{-3}
	Meter/second	5.08×10^{-3}
	Mile/hour	0.01136364 (1/88)
Foot/second	Kilometer/hour	1.09728
	Knot	0.5924838
	Meter/minute	18.288
	Meter/second	0.3048
	Mile/hour	0.6818182
Foot/square second	Kilometer/(hour x second)	1.09728
	Meter/square second	0.3048
	Mile/(hour x second)	0.6818182
Foot to the fourth power	Meter to the fourth power	8.630975×10^{-3}
Foot-candle	Lumen/square foot	1
	Lumen/square meter	10.76391
	Lux	10.76391
Foot-lambert	Candela/square centimeter	$3.4262559 \times -10^{-4}$
	Candela/square meter	3.426259
	Lambert	1.076391×10^{-3}
	Meter-lambert	10.76391
Foot-poundal	Btu	3.99411×10^{-5}
	Calorie	0.0100650
	Foot-pound-force	0.0310810
	Joule	0.0421401
	Kilogram-force-meter	4.29710×10^{-3}
	Liter-atmosphere	4.15891×10^{-4}
	Watt-hour	1.17056×10^{-5}
Foot-pound-force	Btu	1.28507×10^{-3}
	Calorie	0.323832
	Cubic foot-atmosphere	4.72541×10^{-4}
	Foot-poundal	32.1740
	Horsepower-hour	5.05051×10^{-7}
	Horsepower-hour (metric)	5.12055×10^{-7}
	Joule	1.35582
	Kilogram-force-meter	0.138255
	Liter-atmosphere	0.0133809
	Newton-meter	1.35582
	Watt-hour	3.76616×10^{-4}
Foot-pound-force/hour	Watt	3.76616×10^{-4}
Foot-pound-force/minute	Horsepower	3.03030×10^{-5}
	Horsepower (metric)	3.07233×10^{-5}
	Watt	0.0225970
Foot-pound-force/second	Horsepower	1.81818×10^{-3}
	Horsepower (metric)	1.84340×10^{-3}
	Watt	1.355818
Franklin	Coulomb	3.335641×10^{-10}
Furlong	Foot	660
	Meter	201.168
	Mile (statute)	0.125 (1/8)
	Yard	220

G

Gal	Centimeter/square second	1
	Meter/square second	0.01
Gallon (Brit.)	Bushel (Brit.)	0.125 (1/8)
	Cubic centimeter	4546.09
	Cubic foot	0.1605437
	Cubic inch	277.4194
	Cubic yard	5.946061×10^{-3}
	Drachm (Brit., fluid)	1280
	Gallon (U.S.)	1.200950
	Gill (Brit.)	32
	Liter	4.54609
	Minim (Brit.)	76800
	Ounce (Brit., fluid)	160
	Peck (Brit.)	0.5
	Pint (Brit.)	8
	Quart (Brit.)	4
Gallon (U.S., dry)	Bushel (U.S.)	0.125 (1/8)

TO CONVERT FROM	TO	MULTIPLY BY
	Cubic inch	268.8025
	Liter	4.404884
Gallon (U.S., liquid)	Barrel (petroleum)	0.02380952 (1/42)
	Cubic centimeter	3785.412
	Cubic foot	0.13368056
	Cubic inch	231
	Cubic yard	4.951132×10^{-3}
	Dram (U.S., fluid)	1024
	Gallon (Brit.)	0.8326742
	Gill (U.S.)	32
	Liter	3.785412
	Minim (U.S.)	61440
	Ounce (U.S., liquid)	128
	Pint (U.S., liquid)	8
	Quart (U.S., liquid)	4
Gallon (Brit.)/minute	Cubic foot/hour	9.632619
	Cubic foot/second	2.675728×10^{-3}
	Cubic meter/hour	0.2727654
	Liter/second	0.07576817
Gallon (U.S.)/minute	Cubic foot/hour	8.020834
	Cubic foot/second	2.228009×10^{-3}
	Cubic meter/hour	0.2271247
	Liter/second	0.06309020
Gamma	Tesla	1×10^{-9}
Gauss	Tesla	1×10^{-4}
	Weber/square meter	1×10^{-4}
Geepound	Slug	1
Gigawatt-hour	Kilowatt-hour	1×10^{6}
Gilbert	Ampere	0.7957747
Gill (Brit.)	Cubic/centimeter	142.0653
	Cubic inch	8.669357
	Gallon (Brit.)	0.03125 (1/32)
	Gill (U.S.)	1.200950
	Milliliter	142.0653
	Ounce (Brit., liquid)	5
	Pint (Brit.)	0.25 (1/4)
	Quart (Brit.)	0.125 (1/8)
Gill (U.S.)	Cubic centimeter	118.2941
	Cubic inch	7.21875
	Gallon (U.S.)	0.03125 (1/32)
	Gill (Brit.)	0.8326742
	Milliliter	118.2941
	Ounce (U.S., liquid)	4
	Pint (U.S., liquid)	0.25 (1/4)
	Quart (U.S., liquid)	0.125 (1/8)
Gon (grade)	Circumference	0.0025 (1/400)
	Degree (angular)	0.9
	Minute (angular)	54
	Radian	0.01570796
	Second	3240
Grain	Carat (metric)	0.32399455
	Dram	0.03657143
	Milligram	64.79891
	Ounce (avoirdupois)	2.285714×10^{-3}
	Ounce (troy)	2.083333×10^{-3} (1/480)
	Pennyweight	0.04166667 (1/24)
	Pound	1.428571×10^{-4}
	Scruple	0.05 (1/20)
Grain/cubic foot	Milligram/liter	2.288352
Grain/gallon (Brit.)	Millgram/liter	14.25377
Grain/gallon (U.S.)	Millgram/liter	17.11806
	Pound/million gallons	142.8571
Gram	Carat (metric)	5
	Dram	0.56438339
	Grain	15.432358
	Kilogram	0.001
	Milligram	1000
	Ounce (avoirdupois)	0.035273962
	Ounce (troy)	0.032150747
	Pennyweight	0.64301493
	Pound	2.2046226×10^{-3}
	Scruple	0.77161792
	Ton (metric)	1×10^{-6}
Gram (centimeter x second)	Poise	1
Gram/cubic centimeter	Kilogram/cubic decimeter	1
	Kilogram cubic meter	1000
	Kilogram/liter	1
	Pound/cubic foot	62.42796
	Pound/cubic inch	0.03612729
	Pound/gallon (Brit.)	10.02241
	Pound/gallon (U.S.)	8.345404
Gram/cubic meter	Grain/cubic foot	0.4369957
Gram/liter	Grain/gallon (Brit.)	70.15689
	Grain/gallon (U.S)	58.41783
	Gram/cubic centimeter	0.001
	Kilogram/cubic meter	1
	Pound/cubic foot	0.0624280
	Pound/gallon (Brit.)	0.0100224
	Pound/gallon (U.S.)	8.34540×10^{-3}
Gram/meter	Ounce/yard	0.03225451
Gram/milliliter	Gram/cubic centimeter	1
Gram/square meter	Ounce/square foot	0.3277058
	Ounce/square yard	0.02949352
Gram/ton (long)	Gram/ton (metric)	0.9842065
	Gram/ton (short)	0.8928571
	Milligram/kilogram	0.9842065
Gram/ton (metric)	Gram/ton (long)	1.016047
	Gram/ton (short)	0.9071847
	Milligram/kilogram	1
Gram/ton (short)	Gram/ton (long)	1.12
	Gram/ton (metric)	1.102311
	Milligram/kilogram	1.102311
Gram-force	Dyne	980.665
	Newton	9.80665×10^{-3}
Gram-force/square centimeter	Pascal	98.0665
Gram-force-centimeter	Erg	980.665
	Joule	9.80665×10^{-5}
Gray	Joule/kilogram	1

H

Hand	Inch	4
Hectare	Acre	2.471054
	Are	100
	Square foot	1.076391×10^{5}
	Square kilometer	0.01
	Square meter	10000
	Square mile	3.861022×10^{-3}
	Square yard	11959.90
Hectogram	Kilogram	0.1
Hectoliter	Cubic meter	0.1
Hefner unit	Candela	0.903
Henry (int.mean)	Henry	1.00049
Henry (int. U.S.)	Henry	1.000495
Hogshead (U.S.)	Gallon (U.S.)	63
Horsepower	Btu/hour	2544.43
	Btu/minute	42.4072
	Btu/second	0.706787
	Foot-pound-force/hour	1.98×10^{6}
	Foot-pound-force/minute	33000
	Foot-pound-force/second	550
	Horsepower (metric)	1.01387
	Joule/second	745.700
	Kilocalorie/hour	641.186
	Kilocalorie/minute	10.6864
	Kilocalorie/second	0.178107
	Kilogram-force-meter/second	76.0402
	Kilowatt	0.745700
Horsepower (boiler)	Kilowatt	9.80950
Horsepower (electric)	Kilowatt	0.746
Horsepower (metric)	Foot-pound-force/second	542.476
	Horsepower	0.986320
	Kilocalorie/hour	632.415
	Kilocalorie/minute	10.54025
	Kilocalorie/second	0.175671
	Kilogram-force-meter second	75
	Kilowatt	0.735499
Horsepower (water)	Kilowatt	0.746043
Horsepower-hour	Btu	2544.43
	Foot-pound-force	1.98×10^{6}
	Horsepower-hour (metric)	1.01387
	Joule	2.68452×10^{6}
	Kilocalorie	641.186
	Kilogram-force-meter	2.73745×10^{5}
	Kilowatt-hour	0.745700
	Megajoule	2.68452

RAMCO®

TO CONVERT FROM	TO	MULTIPLY BY
Horsepower-hour (metric)	Horsepower-hour	0.986320
	Joule	2.64780×10^{6}
	Kilocalorie	632.415
	Kilogram-force-meter	2.7×10^{5}
	Kilowatt-hour	0.735499
	Megajoule	2.64780
Hour (mean solar)	Day	0.04166667(1/24)
	Minute	60
	Second	3600
	Week	5.952381×10^{-3}
Hundredweight (long)	Hundredweight (short)	1.12
	Kilogram	50.80234544
	Pound	112
	Ton (long)	0.05
	Ton (metric)	0.050802345
	Ton (short)	0.056
Hundredweight (short)	Hundredweight (long)	0.89285714
	Kilogram	45.359237
	Pound	100
	Ton (long)	0.044642857
	Ton (metric)	0.045359237
	Ton (short)	0.05

I

Inch	Centimeter	2.54
	Foot	0.08333333(1/12)
	Mil	1000
	Millimeter	25.4
	Yard	0.02777778(1/36)
Inch of Hg (conv.)	Atmosphere	0.0334211
	Foot of H_2O (conv.)	1.132925
	Inch of H_2O (conv.)	13.5951
	Kilogram-force/ square centimeter	0.0345316
	Millibar	33.8639
	Millimeter of H_2O (conv.)	345.316
	Pascal	3386.39
	Pound-force/square inch	0.491154
Inch of H_20 (conv.)	Inch of Hg (conv.)	0.0735559
	Kilogram-force/ square centimeter	2.54×10^{-3}
	Millibar	2.49089
	Millimeter of Hg (conv.)	1.86832
	Pascal	249.089
	Pound-force/square inch	0.0361273
Inch/ °F	Millimeter/ °C	45.72
Inch/hour	Millimeter/minute	0.4233333
	Millimeter/second	7.055556×10^{-3}
	Foot/minute	1.388889×10^{-3}
Inch/minute	Foot/hour	5
	Meter/hour	1.524
	Millimeter/second	0.4233333
Inch/second	Foot/hour	300
	Meter/minute	1.524
Inch to the fourth power	Meter to the fourth power	4.162314×10^{-7}

J

Joule	Btu	9.47817×10^{-4}
	Calorie	0.238846
	Centigrade heat unit	5.26565
	Cubic foot-atmosphere	3.48529×10^{-4}
	Cubic foot-pound-force/ square inch	5.12196×10^{-3}
	Erg	1×10^{7}
	Foot-poundal	23.7304
	Foot-pound-force	0.737562
	Horsepower-hour (metric)	3.72506×10^{-7}
	Kilogram-force-meter	0.101972
	Liter-atmosphere	9.86923×10^{-3}
	Newton-meter	1
	Watt-hour	2.777778×10^{-4}
	Watt-second	1
Joule/°C	Btu/ °F	5.26565×10^{-4}
Joule/gram	Btu/pound	0.429923
	Kilocalorie/kilogram	0.238846
Joule/(gram x °C)	Btu (pound x °F)	0.238846
	Kilocalorie/(kilogram x °C)	0.238846
Joule/hour	Watt	2.777778×10^{-4}
Joule/minute	Watt	0.01666667 (1/60)
Joule/second	Watt	1

K

Kelvin (temp. interval)	°Celsius	1
	°Fahrenheit	1.8
	°Rankine	1
Kilderkin (Brit.)	Gallon (Brit.)	18
Kilocalorie	Btu	3.96832
	Calorie	1000
	Joule	4186.8
Kilocalorie/cubic meter	Btu/cubic foot	0.112370
	Kilojoule/cubic meter	4.1868
Kilocalorie/hour	Watt	1.163
Kilocalorie/(hour x square meter)	Watt/square meter	1.163
Kilocalorie/(hour x square meter x °C)	Watt/(square meter x °C)	1.163
Kilocalorie/(hour x square meter x °C/centimeter)	Watt/(meter x °C)	0.01163
Kilocalorie/kilogram	Btu/pound	1.8
	Joule/gram	4.1868
Kilocalorie/(kilogram x °C)	Btu/(pound x °F)	1
	Kilojoule/(kg x °C)	4.1868
Kilocalorie/minute	Foot-pound-force/second	51.4671
	Horsepower	0.0935765
	Horsepower (metric)	0.0948744
	Watt	69.78
Kilocalorie/second	Kilowatt	4.1868
Kilogram	Grain	15432.358
	Gram	1000
	Hundredweight (long)	0.019684131
	Hundredweight (short)	0.022046226
	Ounce (avoirdupois)	35.273962
	Ounce (troy)	32.150747
	Pound	2.2046226
	Ton (long)	9.8420653×10^{-4}
	Ton (metric)	0.001
	Ton (short)	1.1023113×10^{-3}
Kilogram/cubic meter	Gram/cubic centimeter	0.001
	Gram/liter	1
	Pound/cubic foot	0.06242796
	Pound/cubic inch	3.612729×10^{-5}
Kilogram/meter	Gram/centimeter	10
	Pound/foot	0.6719690
	Pound/inch	0.05599741
Kilogram-force	Dyne	9.80665×10^{5}
	Newton	9.80665
	Pound-force	2.20462
	Poundal	70.9316
Kilogram-force/square centimeter	Atmosphere	0.967841
	Atmosphere (technical)	1
	Bar	0.980665
	Foot of H_2O (conv.)	32.8084
	Inch of Hg (conv.)	28.9590
	Kilogram-force/square millimeter	0.01
	Meter of H_2O (conv.)	10
	Millimeter of Hg (conv.)	735.559
	Newton/square millimeter	0.0980665
	Pascal (N/square meter)	98066.5
	Pound-force/square foot	2048.16
	Pound-force/square inch	14.22334
	Ton-force (long)/square foot	0.914358
	Ton-force (short)/square foot	1.02408
	Ton-force (long)/square inch	6.34971×10^{-3}
	Ton-force (short)/square inch	7.11167×10^{-3}
Kilogram-force/square meter	Pascal	9.80665
Kilogram-force/square millimeter	Newton/square millimeter	9.80665
	Megapascal	9.80665
	Pound-force/square inch	1422.334
Kilogram-force-meter	Btu	9.29491×10^{-3}
	Calorie	2.34228
	Cubic foot-atmosphere	3.41790×10^{-3}
	Erg	9.80665×10^{7}
	Foot-poundal	232.715
	Foot-poundal-force	7.23301
	Horsepower-hour	3.65304×10^{-6}

TO CONVERT FROM	TO	MULTIPLY BY
	Horsepower-hour (metric)	3.70370×10^{-6}
	Joule	9.80665
	Liter-atmosphere	0.0967841
	Newton-meter	9.80665
	Watt-hour	2.72407×10^{-3}
Kilometer	Astronomical unit	6.68459×10^{-9}
	Foot	3280.840
	Light year	1.05702×10^{-13}
	Mile (nautical)	0.5399568
	Mile (statute)	0.6213712
	Yard	1093.613
Kilometer/hour	Foot/minute	54.68066
	Foot/second	0.9113444
	Inch/second	10.93613
	Knot	0.5399568
	Meter/minute	16.66667
	Meter/second	0.2777778
	Mile/hour	0.6213712
Kilometer/(hour x second)	Centimeter/square second	27.77778
	Foot/square second	0.9113444
	Meter/square second	0.2777778
	Mile/(hour x second)	0.6213712
Kilopascal	Pound-force/square foot	20.8854
	Pound-force/square inch	0.1450377
Kilopond	Kilogram-force	1
	Newton	9.80665
Kilowatt	Btu/hour	3412.14
	Btu/minute	56.8690
	Btu/second	0.947817
	Foot-pound-force/hour	2.65522×10^{6}
	Foot-pound-force/minute	44253.7
	Foot-pound-force/second	737.562
	Horsepower	1.34102
	Horsepower (metric)	1.35962
	Joule/hour	3.6×10^{6}
	Joule/minute	60000
	Joule/second	1000
	Kilocalorie/hour	859.845
	Kilocalorie/minute	14.3308
	Kilocalorie/second	0.238846
	Kilogram-force-meter/hour	3.67098×10^{5}
	Kilogram-force-meter/minute	6118.30
	Kilogram-force-meter/ second	101.972
Kilowatt-hour	Btu	3412.14
	Foot-pound-force	2.65522×10^{6}
	Horsepower-hour	1.34102
	Horsepower-hour (metric)	1.35962
	Joule	3.6×10^{6}
	Kilocalorie	859.845
	Kilogram-force-meter	3.67098×10^{5}
	Megajoule	3.6
Kilowatt-hour/pound	Btu/pound	3412.14
	Joule/gram	7936.641
	Kilocalorie/kilogram	1895.63
Kilowatt-hour/kilogram	Btu/pound	1547.72
Kip	Pound-force	1000
Kip/square inch	Newton/square millimeter	6.89476
	Megapascal	6.89476
Knot	Foot/minute	101.2686
	Foot/second	1.687810
	Kilometer/hour	1.852
	Meter/minute	30.86667
	Meter/second	0.5144444
	Mile (nautical)/hour	1
	Mile (statute)/hour	1.150779
	Candela/square foot	295.7196
	Candela/square inch	2.053608
	Candeala/square meter	3183.099
	Foot-lambert	929.0304

L

Langley	Joule/square meter	41840
Last (Brit.)	Gallon (Brit.)	640
League (nautical)	Mile (nautical)	3
League (statute)	Mile (statute)	3
Light year	Astronomical unit	63239.7
	Kilometer	9.46053×10^{12}
	Mile	5.87850×10^{12}
	Parsec	0.306595
Line	Inch	0.1 or 0.083333
	Millimeter	2.54 or 2.116667
Line	Weber	1×10^{-8}
Link	Chain	0.01
Liter	Bushel (Brit.)	0.027496156
	Bushel (U.S.)	0.02837759
	Cubic centimeter	1000
	Cubic decimeter	1
	Cubic foot	0.03531467
	Cubic inch	61.02374
	Cubic meter	0.001
	Cubic yard	1.307951×10^{-3}
	Drachm (Brit., fluid)	281.5606
	Dram (U.S., fluid)	270.5122
	Gallon (Brit.)	0.21996925
	Gallon (U.S.)	0.26417205
	Gill (Brit.)	7.039016
	Gill (U.S.)	8.453506
	Milliliter	1000
	Minim (Brit.)	16893.64
	Minim (U.S.)	16230.73
	Ounce (Brit., fluid)	35.19508
	Ounce (U.S., fluid)	33.81402
	Pint (Brit.)	1.759754
	Pint U.S., dry)	1.816166
	Pint (U.S., liquid)	2.113376
	Quart (Brit.)	0.8798770
	Quart (U.S., dry)	0.9080830
	Quart (U.S., liquid)	1.056688
Liter (1901-1964)	Cubic decimeter	1.000028
Liter/minute	Cubic foot/hour	2.118880
	Cubic foot/second	5.8858778×10^{-4}
	Gallon (Brit.)/hour	13.19815
	Gallon (Brit.)/second	3.66154×10^{-3}
	Gallon (U.S.)/hour	15.85032
	Gallon (U.S.)/second	4.402868×10^{-3}
Liter/second	Cubic-foot/hour	127.1328
	Cubic-foot/minute	2.118880
	Gallon (Brit.)/hour	791.8893
	Gallon (Brit.)/minute	13.19815
	Gallon (U.S.)/hour	951.0194
	Gallon(U.S.)/minute	15.85032
Liter-atmosphere	Btu	0.0960376
	Calorie	24.2011
	Cubic foot-atmosphere	0.0353147
	Cubic foot-pound-force/ square inch	0.518983
	Foot-poundal	2404.48
	Foot-pound-force	74.7335
	Horsepower-hour	3.77442×10^{-6}
	Horsepower-hour (metric)	3.82677×10^{-6}
	Joule	101.325
	Kilogram-force-meter	10.3323
	Watt-hour	0.0281458
Liter-bar	Joule	100
Lumen/square centimeter	Lux	10000
	Phot	1
Lumen/square foot	Lux	10.76391
Lumen/square meter	Lumen/square foot	0.09290304
	Lux	1
Lux	Lumen/square meter	1
	Phot	1×10^{-4}

M

Maxwell	Weber	1×10^{-8}
Megajoule	Kilowatt-hour	0.2777778
Megapascal	Bar	10
	Newton/square millimeter	1
Megohm	Ohm	1×10^{6}
Meter	Angstrom	1×10^{10}
	Fathom	0.5468066
	Foot	3.2808399
	Foot (U.S. Survey)	3.2808333
	Inch	39.37007874
	Micrometer	1×10^{6}
	Mile (nautical)	5.399568×10^{-4}
	Mile (statute)	6.213712×10^{-4}
	Nanometer	1×10^{9}
	Yard	1.093613298
Meter/hour	Foot/minute	0.05468066
	Foot/second	9.113444×10^{-4}

TO CONVERT FROM	TO	MULTIPLY BY
	Millimeter/minute	16.66667
	Milimeter/second	0.2777778
Meter/minute	Foot/second	0.05468066
	Kilometer/hour	0.06
	Knot	0.03239741
	Mile (statute)/hour	0.03728227
	Millimeter/second	16.66667
Meter/second	Foot/minute	196.8504
	Kilometer/hour	3.6
	Kilometer/minute	0.06
	Knot	1.943844
	Mile (statute)/hour	2.2369636
	Mile (statute)/minute	0.03728227
Meter/square second	Foot/square second	3.280840
	Kilometer (hour x second)	3.6
	Mile/(hour x second)	2.236936
Meter-candle	Lux	1
Mho (ohm $^{-1}$)	Siemens	1
Microfarad	Farad	1×10^{-6}
Mircogram	Grain	1.5432358×10^{-5}
	Gram	1×10^{-6}
Micrometer	Angstro	10000
	Mil	0.03937008
	Millimeter	0.001
	Nanometer	1000
Micron	Micrometer	1
Mil	Inch	0.001
	Micrometer	25.4
	Millimeter	0.0254
Mile (nautical)	Foot	6076.1155
	Kilometer	1.852
	Mile (statute)	1.150779
	Yard	2025.372
Mile (statute)	Chain (Gunter's)	80
	Chain (Ramsden's)	52.8
	Foot	5280
	Furlong	8
	Inch	63360
	Kilometer	1.609344
	Light year	1.70111×10^{-13}
	Meter	1609.344
	Mile (nautical)	0.86897624
	Parsec	5.21552×10^{-14}
	Rod	320
	Yard	1760
Mile (U.S. Survey)	Meter	1609.3472187
Mile/gallon (Brit.)	Kilometer/liter	0.354006
Mile/gallon (U.S.)	Kilometer/liter	0.425144
Mile/hour	Foot/minute	88
	Foot/second	1.466667
	Kilometer/hour	1.609344
	Knot	0.8689762
	Meter/minute	26.8224
	Meter/second	0.44704
Mile/(hour x minute)	Centimeter/square second	0.7450667
Mile/hour x second)	Centimeter/square second	44.704
Mile/minute	Foot/second	88
	Kilometer/hour	96.56064
	Knot	52.13857
	Meter/second	26.8224
Millibar	Pascal	100
Milligram	Carat (metric)	0.005
	Dram	5.6438339×10^{-4}
	Grain	0.015432358
	Ounce (avoirdupois)	3.5273962×10^{-5}
	Ounce (troy)	3.2150747×10^{-5}
	Pennyweight	6.4301493×10^{-4}
	Pound	2.2046226×10^{-6}
	Scruple	7.7161792×10^{-4}
Milligram/assay ton (Brit.)	Milligram/kilogram	30.612245
	Ounce(troy)/ton (long)	1
Milligram/assay ton (U.S.)	Milligram/kilogram	34.28714
	Ounce(troy)/ton (short)	1
Milligram/kilogram	Gram/ton (metric)	1
	Pound (short)	0.002
Milligram/liter	Grain/gallon (Brit.)	0.07015689
	Grain/gallon (U.S.)	0.05841783
	Gram/cubic meter	1
	Pound/cubic foot	6.242796×10^{-5}
Milligram/cubic meter	Grain/cubic foot	4.369957×10^{-4}
Milligram-force	Dyne	0.980665
	Newton	9.80665×10^{-6}
Milligram-force/centimeter	Dyne/centimeter	0.980665
	Newton/meter	9.80665×10^{-4}
Milligram-force/inch	Dyne/centimeter	0.386089
	Newton/meter	3.86089×10^{-4}
Milliliter	Cubic centimeter	1
Millimeter	Angstrom	1×10^{7}
	Inch	0.03937008
	Micrometer	1000
Millimeter of Hg (conv.)	Atmosphere	1.315789×10^{-3}
	Dyne/square centimeter	1333.224
	Foot of H_2O (conv.)	0.0446033
	Gram-force/square centimeter	1.35951
	Millibar	1.333224
	Millimeter of H_2O (conv.)	13.5951
	Pascal	133.3224
	Pound-force/square foot	2.78450
	Pound-force/square inch	0.0193368
	Torr	1
Millimeter of H2O (conv.)	Atmosphere	9.67841×10^{-3}
	Gram-force/square centimeter	0.1
	Millibar	0.0980665
	Millimeter of Hg (conv.)	0.0735559
	Pascal	9.80665
	Pound-force/square inch	1.42233×10^{-3}
Millimicron	Nanometer	1
Minim (Brit.)	Drachm (Brit., fluid)	0.01666667 (1/60)
	Milliliter	0.05919388
	Minim (U.S.)	0.9607599
	Ounce (Brit., fluid)	2.083333×10^{-3}
Minim (U.S.)	Dram (U.S., fluid)	0.01666667 (1/60)
	Milliliter	0.06161152
	Minim (Brit.)	1.040843
	Ounce (U.S., fluid)	2.083333×10^{-3}
Minute	Day	6.944444×10^{-4}
	Hour	0.01666667 (1/60)
	Second	60
	Week	9.920635×10^{-5}
Minute (angular)	Circumference	4.62930×10^{-5}
	Degree (angular)	0.01666667 (1/60)
	Gon (grade)	0.01851852 (1/54)
	Quadrant	1.851852×10^{-4}
	Radian	2.90882×10^{-4}
	Second (angular)	60
Month (mean of 4-year period)	Day	30.4375
	Hour	730.5
	Minute	43830
	Second	2.6298×10^{6}
	Week	4.348214

N

Nail (Brit.)	Inch	2.25
Nanometer	Angstrom	10
	Micrometer	0.001
	Mil	3.937008×10^{-5}
Neper	Decibel	8.685890
Newton	Dyne	1×10^{5}
	Kilogram-force	0.1019716
	Poundal	7.23301
	Pound-force	0.224809
Newton/square centimeter	Newton/square millimeter	0.01
	Pascal	10000
Newton/square meter	Pascal	1
Newton/square millimeter	Kilogram-force/square millimeter	0.1019716
	Megapascal	1
	Ton-force (metric)/square meter	101.9716
Newton-meter	Foot-pound-force	0.737562
	Joule	1
	Kilogram-force-meter	0.1019716
	Watt-hour	2.777778×10^{-4}
	Watt-second	1
Nit	Candela/square meter	1
Noggin (Brit.)	Gill (Brit.)	1
Nox	Lux	0.001

O

Oersted	Ampere/meter	79.57747
Ohm (int. mean)	Ohm	1.00049

TO CONVERT FROM	TO	MULTIPLY BY
Ohm (int. U.S.)	Ohm	1.000495
Ohm/foot	Ohm/meter	3.280840
Ohm-centimeter	Ohm-meter	0.01
Ohm-circular mil/foot	Ohm-meter	1.662426×10^{-9}
Ohm-meter	Ohm-square millimeter/meter	1×10^{6}
Ohm-square millimeter/meter	Ohm-meter	1×10^{-6}
Ounce (avoirdupois)	Dram	16
	Grain	437.5
	Gram	28.349523
	Ounce (apot. or troy)	0.91145833
	Pennyweight	18.229167
	Pound	0.0625 (1/16)
	Scruple	21.875
Ounce (troy or ap.)	Grain	480
	Gram	31.1034768
	Ounce (avoirdupois)	1.0971429
	Pennyweight	20
	Pound (avoirdupois)	0.068571429
	Scruple	24
Ounce (Brit., fluid)	Cubic centimeter	28.41306
	Cubic inch	1.733871
	Drachm (Brit., fluid)	8
	Dram (U.S., fluid)	7.686079
	Gallon (Brit.)	6.25×10^{-3} (1/160)
	Gill (Brit.)	0.2
	Milliliter	28.41306
	Minim (Brit.)	480
	Ounce (U.S., fluid)	0.9607599
	Pint (Brit.)	0.05
	Quart (Brit.)	0.025 (1/140)
Ounce (U.S., fluid)	Cubic centimeter	29.57353
	Cubic inch	1.8046875
	Dram (U.S., fluid)	8
	Gallon (U.S.)	7.8125×10^{-3}
	Gill (U.S.)	0.25
	Milliliter	29.57353
	Minim (U.S.)	480
	Ounce (Brit., fluid)	1.040843
	Pint (U.S., liquid)	0.0625 (1/16)
	Quart (U.S., liquid)	0.03125 (1/32)
Ounce (avoirdupois)/cubic foot	Kilogram/ cubic meter	1.001154
Ounce (avoirdupois)/cubic inch	Kilogram/cubic meter	1729.994
Ounce (avoirdupois)/gallon (Brit.)	Kilogram/cubic meter	6.236023
Ounce (avoirdupois)/gallon (U.S.)	Kilogram/cubic meter	7.489152
Ounce (avoirdupois)/square foot	Gram/square meter	305.1517
Ounce (avoirdupois)/square yard	Gram/square meter	33.90575
Ounce (avoirdupois)/ton (long)	Gram/ton (metric)	27.90179
	Milligram/kilogram	27.90179
Ounce (avoirdupois)/ton (short)	Gram/ton (metric)	31.25
	Milligram/kilogram	31.25
Ounce (avoirdupois)/yard	Gram/meter	31.00342
Ounce-force (avoirdupois)	Newton	0.2780139
Ounce-force (avoirdupois)/ square inch	Pascal	430.922
Ounce-force (avoirdupois)-inch	Newton-meter	7.06155×10^{-3}

P

Pace	Foot	2.5
Palm	Inch	3
Parsec	Astronomical unit	2.06265×10^{5}
	Kilometer	3.0857×10^{13}
	Light year	3.26164
	Mile (statute)	1.91735×10^{13}
Part per million	Gram/ton (metric)	1
	Milligram/kilogram	1
	Milliliter/cubic meter	1
	Ounce (avoirdupois)/ton (long)	0.03584
	Ounce (avoirdupois)/ton (short)	0.032
	Ounce (troy)/ton (long)	0.03266667
	Ounce (troy)/ton (short)	0.02916667
Pascal	Atmosphere	9.869233×10^{-6}
	Bar	1×10^{-5}
	Dyne/square centimeter	10
	Foot of H_20 (conv.)	3.34552×10^{-4}
	Inch of Hg (conv.)	2.95300×10^{-4}
	Inch of H_20 (conv.)	4.01463×10^{-3}
	Kilogram-force/square centimeter	1.01972×10^{-5}
	Millibar	0.01
	Millimeter of Hg (conv.)	7.50062×10^{-3}
	Millimeter of H_20 (conv.)	0.101972
	Newton/square meter	1
	Newton/square millimeter	1×10^{-6}
	Poundal/square foot	0.671969
	Pound-force/square foot	0.0208854
	Pound-force/square inch	1.45038×10^{-4}
	Torr	7.50062×10^{-3}
Pascal-second	Poise	10
Peck (Brit.)	Gallon (Brit.)	2
Peck (U.S.)	Bushel (U.S.)	0.25
	Quart (U.S., dry)	8
Pennyweight	Dram	0.87771429
	Grain	24
	Gram	1.55517384
	Ounce (avoirdupois)	0.054857143
	Ounce (apoth. or troy)	0.05
	Pound	3.4285714×10^{-3}
Perch	Foot	16.5
Phot	Lux	10000
Pica (printer's)	Point (printer's)	12
Picofarad	Farad	1×10^{-12}
Pint (Brit.)	Cubic centimeter	568.26125
	Cubic inch	34.67743
	Gallon (Brit.)	0.125 (1/8)
	Gill (Brit.)	4
	Liter	0.56826125
	Milliliter	568.26125
	Ounce (Brit., fluid)	20
	Pint (U.S., dry)	1.032057
	Pint (U.S., liquid)	1.200950
	Quart (Brit.)	0.5
Pint (U.S., dry)	Bushel (U.S.)	0.015625 (1/64)
	Cubic centimeter	550.6105
	Cubic inch	33.6003125
	Liter	0.5506105
	Milliliter	550.6105
	Peck (U.S.)	0.0625 (1/16)
	Pint (Brit.)	0.9689390
	Quart (U.S., dry)	0.5
Pint (U.S., liquid)	Cubic centimeter	473.1765
	Cubic inch	28.875
	Gallon (U.S)	0.125 (1/8)
	Gill (U.S.)	4
	Liter	0.4731765
	Milliliter	473.1765
	Ounce (U.S., fluid)	16
	Pint (Brit.)	0.8326742
	Quart (U.S., liquid)	0.5
Point (printer's, Didot)	Millimeter	0.3760650
Point (printer's, U.S.)	Inch	0.013837
	Milliliter	0.3514598
Poise	Dyne-second/square centimeter	1
	Gram/centimeter x second)	1
	Pascal-second	0.1
Pole (Brit.)	Foot	16.5
Pond	Gram-force	1
Pottle (Brit.)	Gallon (Brit.)	0.5
Pound (avoirdupois)	Dram	256
	Grain	7000
	Gram	453.59237
	Hundredweight (long)	8.9285714×10^{-3}
	Hundredweight (short)	0.01
	Kilogram	0.45359237
	Ounce (avoirdupois)	16
	Ounce (troy)	14.583333
	Pennyweight	291.66667
	Pound (troy)	1.2152778
	Scruple	350
	Stone (Brit.)	0.07142857 (1/14)
	Ton (long)	4.4642857×10^{-4}
	Ton (metric)	4.5359237×10^{-4}
	Ton (short)	5×10^{-4} (1/2000)
Pound (troy)	Dram (troy)	96
	Grain	5760
	Gram	373.2417216
	Ounce (troy)	12
	Pennyweight	240
	Pound (avoirdupois)	0.82285714

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TO CONVERT FROM	TO	MULTIPLY BY
	Scruple	288
Pound/acre	Kilogram/hectare	1.120851
Pound/cubic foot	Gram/liter	16.01846
	Kilogram/cubic meter	16.01846
	Pound/cubic inch	5.787037×10^{-4}
Pound/cubic inch	Gram/cubic centimeter	27.679905
	Pound/cubic foot	1728
Pound/cubic yard	Kilogram/cubic meter	0.5932764
Pound/foot	Kilogram/meter	1.488164
Pound/(foot x hour)	Pascal-second	4.133789×10^{-4}
Pound/(foot x second)	Pascal-second	1.488164
Pound/gallon (Brit.)	Gram/cubic centimeter	0.09977637
	Gram/liter	99.77637
	Kilogram/cubic meter	99.77637
	Pound/cubic foot	6.228835
	Ton (long)/cubic yard	0.07507968
Pound/gallon (U.S.)	Gram/cubic centimeter	0.1198264
	Gram/liter	119.8264
	Kilogram/cubic meter	119.8264
	Pound/cubic foot	7.480519
	Ton (short)/cubic yard	0.1009870
Pound/hour	Gram/minute	7.559873
	Gram/second	0.1259979
	Kilogram/day	10.88622
Pound/horsepower-hour	Kilogram/megajoule	0.1689659
	Kilogram/kilowatt-hour	0.6082774
Pound/inch	Kilogram/meter	17.85797
Pound/minute	Gram/second	7.559873
	Kilogram/hour	27.21554
Pound/second	Kilogram/hour	1632.932
	Kilgram/minute	27.21554
Pound/square foot	Kilogram/square meter	4.882428
Poundal	Gram-force	14.0981
	Newton	0.1382550
	Pound-force	0.0310810
Poundal/square foot	Pascal	1.488164
Poundal-foot	Newton-meter	0.0421401
Poundal-second/square foot	Pascal-second	1.488164
Pound-force	Kilogram-force	0.453592
	Newton	4.44822
	Poundal	32.1740
Pound-force/foot	Newton-meter	14.5939
Pound-force/inch	Newton-meter	175.127
Pound-force/square foot	Atmosphere	4.72541×10^{-4}
	Bar	4.78803×10^{-4}
	Foot H_20 (conv.)	0.0160185
	Gram-force/square centimeter	0.488243
	Inch of Hg (conv.)	0.0141390
	Millimeter of Hg (conv.)	0.359131
	Millimeter of H_20 (conv.)	4.88243
	Pascal	47.8803
	Pound-force/square inch	6.944444×10^{-3}
Pound-force/square inch	Amosphere	0.0680460
	Bar	0.689476
	Foot of H_20 (conv.)	2.30666
	Inch of Hg (conv.)	2.03602
	Kilogram-force/square centimeter	0.0703070
	Meter of H_20 (conv.)	0.703070
	Millibar	68.9476
	Millimeter of Hg (conv.)	51.7149
	Pascal	6894.76
	Pound-force/square foot	144
Pound-force-foot	Newton-meter	1.35582
Pound-force-foot/inch	Newton-meter/meter	53.3787
Pound-force-inch	Newton-meter	0.112985
Pound-force-inch/inch	Newton-meter/meter	4.44822
Pound-force-second/square foot	Pascal-second	47.8803
Pound-force-second/square inch	Pascal-second	6894.76
Psi	Pound-force/square inch	1
Puncheon (Brit.)	Gallon (Brit.)	70

Q

Quadrant	Degree (angular)	90
	Gon (grade)	100
	Minute (angular)	5400
Quart (Brit.)	Cubic centimeter	1136.5225
	Cubic foot	0.04013591
	Cubic inch	69.35486
	Gallon (Brit.)	0.25 (1/4)
	Gill (Brit.)	8
	Liter	1.1365225
	Ounce (Brit., fluid)	40
	Pint (Brit.)	2
	Quart (U.S., dry)	1.032057
	Quart (U.S., liquid)	1.200950
Quart (U.S., dry)	Bushel (U.S.)	0.03125 (1/32)
	Cubic centimeter	1101.221
	Cubic foot	0.03888925
	Cubic inch	67.200625
	Liter	1.101221
	Peck (U.S.)	0.125 (1/8)
	Pint (U.S., dry)	2
	Quart (U.S., liquid)	1.163647
Quart (U.S., liquid)	Cubic centimeter	946.35295
	Cubic foot	0.03342014
	Cubic inch	57.75
	Dram (U.S., fluid)	256
	Gallon (U.S.)	0.25 (1/4)
	Gill (U.S.)	8
	Liter	0.94635295
	Ounce (U.S., fluid)	32
	Pint (U.S., liquid)	2
	Quart (Brit.)	0.8326742
	Quart (U.S., dry)	0.8593670
Quarter (Brit., cap)	Gallon (Brit.)	64
Quarter (Brit., mass)	Pound	28
Quarter (U.S., long)	Pound	560
Quarter (U.S., short)	Pound	500
Quintal	Kilogram	100

R

Rad	Gray	0.01
	Joule/kilogram	0.01
Radian	Degree (angular)	57.295780
	Gon (grade)	63.66198
	Minute (angular)	3437.747
	Revolution	0.1591549
	Second (angular)	2.062648×10^{5}
Radian/centimeter	Degree/millimeter	5.729578
	Degree/foot	1746.375
	Degree/inch	145.5313
Radian/second	Revolution/minute	9.549297
Radian/square second	Revolution/square minute	572.9578
Register ton	Cubic foot	100
	Cubic meter	2.831685
Rem	Sievert	0.01
Revolution	Degree (angular)	360
	Gon (Grade)	400
Revolution/minute	Degree/second	6
Reyn	Pascal-second	6894.76
Rhe	1/pascal-second	10
Right angle	Degree	90
	Gon (grade)	100
Rod	Foot	16.5
Roentgen	Coulomb/kilogram	2.58×10^{-4}
Rood (Brit.)	Acre	0.25 (1/4)
	Square meter	1011.7141
Rope (Brit.)	Foot	20

S

Scruple	Dram (apoth. or troy)	0.3333333 (1/3)
	Grain	20
	Gram	1.2959782
	Ounce (avoirdupois)	0.045714286
	Ounce (apoth. or troy)	0.04166667 (1/24)
	Pennyweight	0.83333333 (10/12)
	Pound	2.857143×10^{-3}
Scruple (Brit., fluid)	Minum (Brit.)	20
Seam (Brit.)	Gallon (Brit.)	64
Second (angular)	Degree	2.777778×10^{-4}
	Gon (grade)	3.086420×10^{-4}
	Minute (angular)	0.01666667 (1/60)
	Radian	4.848137×10^{-6}

TO CONVERT FROM	TO	MULTIPLY BY
Shake	Second	1×10^{-8}
Siemens	Mho (ohm^{-1})	1
Slug	Geepound	1
	Kilogram	14.5939
	Pound	32.1740
Slug/cubic foot	Kilogram/cubic meter	515.379
Slug/(foot x second)	Pascal-second	47.8803
Span	Inch	9
Square centimeter	Circular mil	1.973525×10^{5}
	Circular millimeter	127.3240
	Square foot	1.076391×10^{-3}
	Square inch	0.1550003
	Square meter	1×10^{-4}
	Square millimeter	100
	Square yard	1.195990×10^{-4}
Square chain (Gunter's)	Acre	0.1
	Square foot	4356
	Square meter	404.6856
Square chain (Ramsden's)	Square foot	10000
Square chain (U.S. Survey)	Square meter	404.687261
Square degree	Steradian	3.046174×10^{-4}
Square foot	Acre	2.295684×10^{-5}
	Square centimeter	929.0304
	Square chain (Gunter's)	2.295684×10^{-4}
	Square chain (Ramden's)	1×10^{-4}
	Square inch	144
	Square link (Gunter's)	2.295684
	Square meter	0.09290304
	Square mile	3.587006×10^{-8}
	Square rod	3.673095×10^{-3}
	Square yard	0.1111111 (1/9)
Square foot (U.S. Survey)	Square meter	0.092903412
Square foot/hour	Square meter/second	2.58064×10^{-5}
Square inch	Circular mil	1.273240×10^{6}
	Circular millimeter	821.4432
	Square centimeter	6.4516
	Square foot	6.944444×10^{-3}
	Square millimeter	645.16
Square inch/second	Square foot/minute	0.4166667
	Square meter/hour	2.322576
Square/kilometer	Acre	247.1054
	Hectare	100
	Square foot	1.076391×10^{7}
	Square meter	1×10^{6}
	Square mile	0.38610216
	Square yard	1.195990×10^{6}
Square link (Gunter's)	Square foot	0.4356
Square link (Ramsden's)	Square foot	1
Square meter	Acre	2.471054×10^{-4}
	Are	0.01
	Hectare	1×10^{-4}
	Square centimeter	10000
	Square chain (Gunter's)	2.471054×10^{-3}
	Square foot	10.76391
	Square inch	1550.003
	Square kilometer	1×10^{-6}
	Square link (Gunter's)	24.71054
	Square mile	3.861022×10^{-7}
	Square yard	1.195990
Square mil	Circular mil	1.273240
	Square inch	1×10^{-6}
	Square micrometer	645.16
	Square millimeter	6.4516×10^{-4}
Square mile	Acre	640
	Square chain (Gunter's)	6400
	Square foot	2.78784×10^{7}
	Square kilometer	2.589988110
	Square meter	2.589988×10^{6}
	Square rod	1.024×10^{5}
	Square yard	3.0976×10^{6}
	Township	0.02777778 ((1/36)
Square mile (U.S. Survey)	Square kilometer	2.589998470
Square millimeter	Circular mil	1973.525
	Circular millimeter	1.273240
	Square centimeter	0.01
	Square inch	1.550003×10^{-3}
	Square mil	1550.003
Square rod	Acre	0.00625 (1/160)
	Square foot	272.25
	Square meter	25.29285
Square yard	Acre	2.066116×10^{-4}
	Square foot	9
	Square inch	1296
	Square meter	0.83612736
	Square mile	3.228306×10^{-7}
Standard (Petrograd)	Cubic foot	165
Statampere	Ampere	3.335641×10^{-10}
Statcoulomb	Coulomb	3.335641×10^{-10}
Statfarad	Farad	1.112650×10^{-12}
Stathenry	Henry	8.987552×10^{11}
Statmho	Siemens	1.112650×10^{-12}
Statohm	Ohm	8.987552×10^{11}
Statvolt	Volt	299.7925
Steradian	Square degree	3282.806
Stere	Cubic meter	1
Stilb	Candela/square centimeter	1
Stokes	Square meter/second	1×10^{-4}
Stone	Pound	14

T

Tablespoon (metric)	Milliliter	15
Tablespoon (U.S.)	Milliliter	14.79
Teaspoon (metric)	Milliliter	5
Teaspoon (U.S.)	Milliliter	4.93
Terawatt-hour	Kilowatt-hour	1×10^{9}
Tesla	Weber/square meter	1
Tex	Denier	9
	Gram/kilometer	1
Therm	Btu	1×10^{5}
Thou	Mil	1
Ton (assay, Brit.)	Gram	32.66667
Ton (assay, U.S.)	Gram	29.16667
Ton (long)	Hundredweight (long)	20
	Hundredweight (short)	22.4
	Kilogram	1016.0469088
	Pound	2240
	Ton (metric)	1.0166047
	Ton (short)	1.12
Ton (metric)	Hundredweight (long)	19.684131
	Hundredweight (short)	22.046226
	Kilogram	1000
	Pound	2204.6226
	Ton (long)	0.98420653
	Ton (short)	1.1023113
Ton (short)	Hundredweight (long)	17.857143
	Hundredweight (short)	20
	Kilogram	907.1874
	Pound	2000
	Ton (long)	0.89285714
	Ton (metric)	0.90718474
Ton (long)/cubic yard	Kilogram/cubic meter	1328.939
Ton (metric)/cubic meter	Gram/cubic centimeter	1
	Kilogram/cubic decimeter	1
Ton (short)/cubic yard	Kilogram/cubic meter	1186.553
Ton-force (long)	Newton	9964.02
Ton-force (metric)	Newton	9806.65
Ton-force (short)	Newton	8896.44
Ton-force (long)/square foot	Atmosphere	1.05849
	Bar	1.07252
	Kilogram-force/square centimeter	1.09366
	Newton/square millimeter	0.107252
	Pascal	1.07252×10^{5}
	Pound-force/square inch	15.5556
Ton-force(long)/square inch	Atmosphere	152.423
	Bar	154.443
	Kilogram-force/square centimeter	157.488
	Newton/square millimeter	15.4443
	Pascal	1.54443×10^{7}
	Pound-force/square inch	2240
Ton-force (metric)/square meter	Atmosphere	0.0967841
	Bar	0.0980665
	Kilogram-force/square centimeter	0.01
	Newton/square millimeter	9.80665×10^{-3}
	Pascal	9806.65
	Pound-force/square inch	1.42233
Ton-force (short)/square foot	Atmosphere	0.945083

TO CONVERT FROM	TO	MULTIPLY BY
	Bar	0.957605
	Kilogram-force/square centimeter	0.976486
	Newton-square millimeter	0.0957605
	Pascal	9.57605×10^{4}
	Pound-force/square inch	13.8889
Ton-force (short)/square inch	Atmosphere	136.092
	Bar	137.895
	Kilogram-force/square centimeter	140.614
	Newton/square millimeter	13.7895
	Pascal	1.37895×10^{7}
	Pound-force/square inch	2000
Tonne	Kilogram	1000
Torr	Millibar	1.333224
	Millimeter of Hg (conv.)	1
	Pascal	133.3224
Township (U.S.)	Square kilometer	93.23957
	Square mile	36

U

Unit pole	Weber	1.256637×10^{-7}

V

Volt (int.mean)	Volt	1.00034
Volt (int. U.S.)	Volt	1.000330
Volt/inch	Volt/meter	39.37008
Volt-second	Weber	1

W

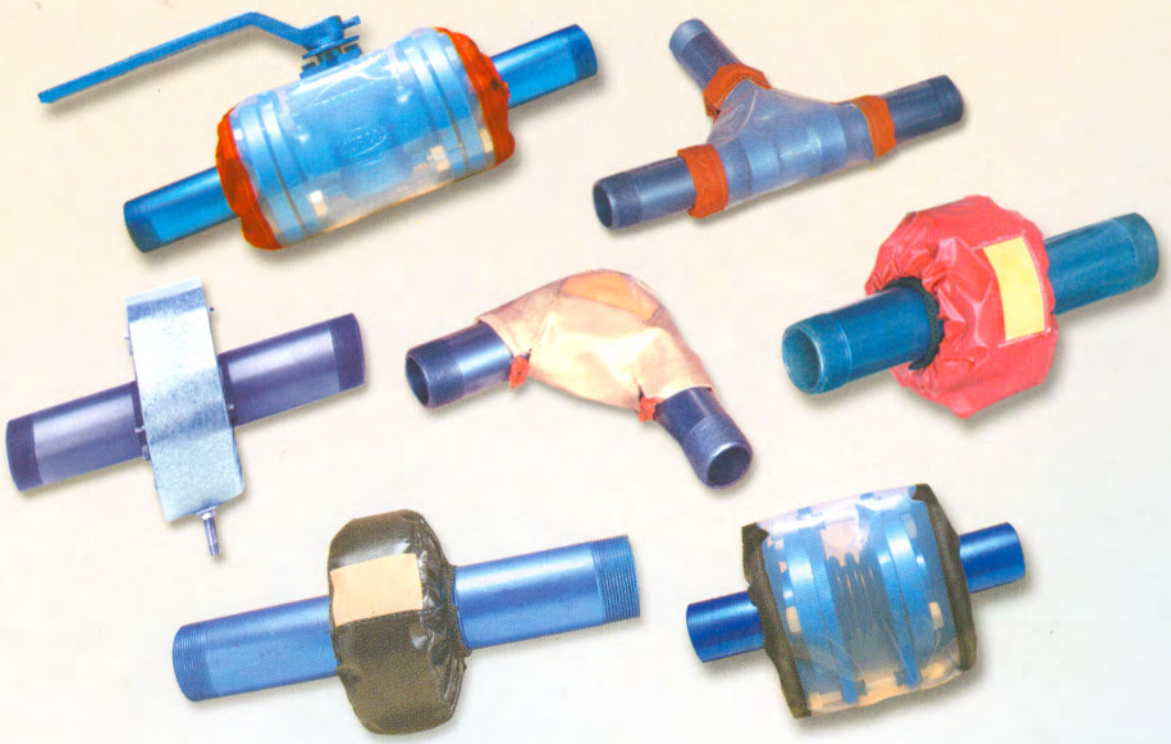
Watt	Btu/hour	3.41214
	Btu/minute	0.0568690
	Caloric/minute	14.3308
	Caloric/second	0.238846
	Erg/second	1×10^{7}
	Foot-pound-force/minute	44.2537
	Foot-pound-force/second	0.737562
	Horsepower	1.34102×10^{-3}
	Horsepower (metric)	1.35962×10^{-3}
	Joule/second	1
	Kilocalorie/hour	0.859845
	Kilogram-force-meter/second	0.101972
Watt (int. mean)	Watt	1.00019
Watt (int. U.S.)	Watt	1.000165
Watt/square inch	Btu/(hour x square foot)	491.348
	Kilocalorie/(hour x square meter)	1332.76
	Watt/square meter	1550.003
Watt/square meter	Kilocalorie/(hour x square meter)	0.859845
Watt-hour	Btu	3.41214
	Calorie	859.845
	Foot-pound-force	2655.22
	Horsepower-hour	1.34202×10^{-3}
	Horsepower-hour (metric)	1.35962×10^{-3}
	Joule	3600
	Kilogram-force-meter	367.098
	Liter-atmosphere	35.5292
Watt-second	Erg	1×10^{7}
	Joule	1
	Newton-meter	1
Weber	Maxwell	1×10^{8}
Weber/square meter	Gauss	10000
Week	Day	7
	Hour	168
	Minute	10080
	Month	0.2299795
	Second	6.048×10^{5}

X

X-unit	Meter	1.00202×10^{-13}

Y

Yard	Centimeter	91.44
	Fathom	0.5
	Foot	3
	Inch	36
	Meter	0.9144
	Mile	5.681818×10^{-4}
Year (calendar, mean of 4-year period)	Day	365.25
	Hour	8766
	Minute	5.2596×10^{5}
	Second	3.15576×10^{7}
	Week	52.17857
Year (leap)	Day	366
Year (normal calendar)	Day	365
	Hour	8760
	Minute	5.256×10^{5}
	Second	3.1536×10^{7}
	Week	52.14286
Year (sidereal)	Day	365.25636
	Second	3.155815×10^{7}
	Year (tropical)	1.0000388
Year (tropical)	Day	365.24220
	Second	3.1556926×10^{7}
	Year (sidereal)	0.9999612



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SYSTEM CERTIFICATION ISO 9001:2000 SGS