

Toxic substances control is here

This long-expected new U.S. law—which was passed last October—features remedies much better than those proposed in previously recommended legislation. Here's how compliance can occur

Curtis W. Smith,
Shell Oil Co., Houston

THE NEW TOXIC Substances Control Act (TSCA) will have a major impact on hydrocarbon processing operations. This Act—and what industry is doing to meet its requirements—should be understood by plant managers, their department heads and safety professionals.

Here, I will deal with five areas: (1) Changes already taking place to provide greater safety from chemicals, (2) Major features of the Act, (3) Economic impact of the Act, (4) The Office of Toxic Substances set up to administer the Act and (5) A new Manufacturing Chemists Association's Chemical Regulations Advisory Committee set up to serve as a focus for MCA to deal with the Act.

CHANGES TO IMPROVE SAFETY

If we choose to believe many newspaper articles, TV reports and books, we must conclude the sky of toxic substances is falling and nothing is being done about it. But things are being done to reduce chemical hazards, especially those related to the Toxic Substances Control Act. I am not saying that the struggle is over. But a definite beginning has been made. As we work together, the problem can be solved.

One area of progress is legislation.

For 40 years, there was only one law in this area, the Food, Drug and Cosmetic Act. As you can see from Fig. 1, the number of major laws has increased markedly. There are laws to protect workers, consumers, drinking water, air, food, transportation and storage, and to guarantee

testing of existing and new materials and to regulate their manufacture and use accordingly. Under TSCA, much thought was given as to how to coordinate the administration of these laws. Goal: to develop most effective action and minimize confusing overlap.

Most existing chemicals have been studied to determine whether short-term exposure causes illness or death. But the hazards from long-term exposure to commodity chemicals have only been appreciated for a few years. These tests require lifetime studies with hundreds of animals (2-3 years

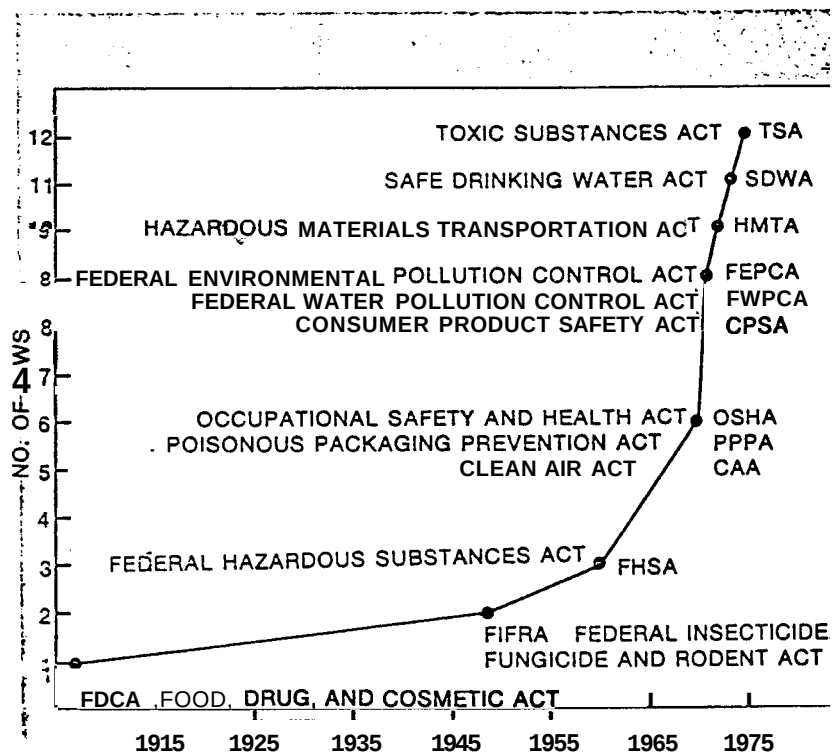


Fig. 1—Since 1915, a dozen toxicology and safety-related laws have been passed which impact upon HPI operations.

002229

TOXIC SUBSTANCES CONTROL IS HERE

PRODUCTS	ACUTE	SUB-ACUTE	CHRONIC-ORAL	CHRONIC--INHAL.	CHRONIC--DERMAL	REPRODUCTION	TERATOGENICITY	METABOLISM	MUTAGENICITY	ENVIRONMENTAL	HUMAN---	STATUS REPORT--
ALLYL CHLORIDE	MCA P	MCA P	MCA P			MCA P		MCA P				
EPICHLOROHYDRIN	MCA P	MCA C	MCA C			MCA C		MCA C				
VINYL CHLORIDE MONOMER	MCA	MCA	MCA 18			MCA U		MCA U		FDA U12		
ETHYLENE OXIDE	JIS S77	JIS S77	JIS S77			JIS S77		JIS S77				F
BUTADIENE			SR S77			SR S77		SR S77				
ETHYLENE	CIT U	CIT U	CIT U			CIT C		CIT C				IP
HEXANE			CIT P									IP
TOLUENE			CIT U									IP
STYRENE			MCA U18			MCA U		MCA U				
ETHYLENE DICHLORIDE			MCA U18			MCA U12		MCA U12				
METHYLENE CHLORIDE			DOW			DOW		DOW				IP
PHENOL												P

P = PUNNING STAGE
C = READY TO CONTRACT
U = UNDERWAY
U-18 = UNDERWAY 18 MONTHS
JIS = JOINT INTERNATIONAL STUDY
SR = INTERNATIONAL INSTITUTE OF SYNTHETIC RUBBER

S = EXPECTED STARTING DATE
F = FINAL
IP = IN PROGRESS
STATUS REPORT = LITERATURE SURVEY
-- = CHRONIC INCLUDES CARCINOGENIC EVALUATION
--- = HUMAN-CHRONIC ORAL

Fig. 2—These activities are underway by the Chemical Industry Institute of Toxicology (CIIT), Manufacturing Chemists Association (MCA) and others.

with mice or rats) and are expensive. To carry them out requires greatly increased laboratory facilities and commitment of people. Let me discuss changes being made in this area.

CIIT formed. A new Chemical Industry Institute of Toxicology (CIIT) has been established by industry. It will conduct toxicologic studies and research. Guarantees are built in to protect the scientific integrity of the laboratory. It will express the voice of science and not the commercial interests of industry. Already some 22 companies have joined the organization. Others are invited. Contracts for long-term studies with ethylene and toluene have been established. Four more contracts should follow soon. More are in various stages of development. Plans are well underway

toward the construction of a \$12-million laboratory.

Major expansions of toxicology laboratories, up to doubling capacity, have been completed at Dow, duPont, Carbide, Stauffer, Shell International in England and Eastman Kodak. Monsanto has announced a new toxicology laboratory. Other companies considering construction of new laboratories are Celanese, Exxon, Gulf and Olin.

The contract laboratories have mostly doubled in size and are operating at capacity.

Joint studies. About \$7 million of jointly supported industrial contracts for long-term studies on commodities have been let over the past 12-18 months. This list is in addition to other continuing studies. (See Fig. 2.)

The estimated cost for individual compounds varies from \$400,000 to \$1 million. Most of these are jointly supported by industry under CIIT, MCA, International Institute of Synthetic Rubber and one joint industry study not under any trade association.

In addition to this, the National Paint and Coatings Association is instituting a \$675,000 epidemiologic study of workers in the paint industry. Many other epidemiologic studies are underway or being planned.

Many industries are examining carefully records of illness and death against exposure for all employees. Where any potential problems are observed, these are brought to the attention of employees, governmental agencies and the press.

Rightly or wrongly, a number of chemicals have already been removed from the market, some by governmental action, some voluntarily.

Now, let me turn to major features of the Act, as shown in Table 1.

TABLE 1—Major features

Existing Substances
• Inventory of existing chemical substances or categories thereof
• Reports from manufacturers or processors for chemical substances and mixtures
o Chemical Substances List
o Priority List
Testing
o May be required by EPA by rule
o Standards set by EPA by rule
o Companies may share expense

MAJOR FEATURES OF ACT

The Act is designed to guarantee testing and regulation of existing and new materials which present unreasonable risk to health or the environment. Chemical substances (individual elements or compounds) are treated differently from mixtures. Mixtures are combinations of substances such as in paints, adhesives, rubber, plastics, etc. In general, it is assumed that the safety of a mixture can be determined from what is known about component substances. When I say materials, I mean both substances and mixtures. In the following discussion, major features of the Act are presented in about the order in which industry will meet them.

• **Reporting.** To establish which materials exist and which are new, an inventory of chemicals and categories will be prepared and submitted to industry for additions. It will be important for domestic and foreign

TOXIC SUBSTANCES CONTROL IS HERE

industry to get their compounds on the inventory. Any substance not there will be treated as new and must go through premarket notification.

Pesticides, tobacco, materials under the Atomic Energy Act, food, drugs and cosmetics are exempt from this Act. Chemicals produced in small quantities or used solely in research and development and mixtures may not need to be listed, reported or given premarket notification. The Adminis-

trator may request information and regulate them where it is needed.

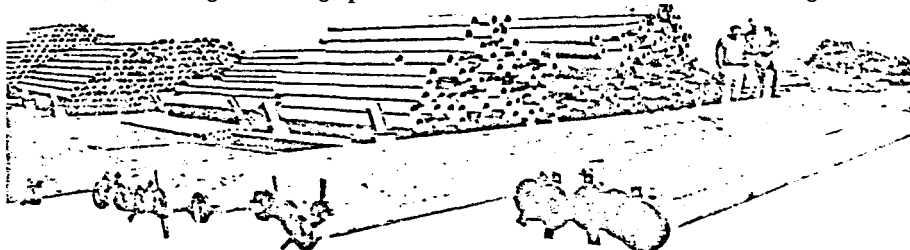
The Administrator may require manufacturers and processors to report on the chemicals substances and mixtures they produce. This may include: chemical identity, categories of use, volumes and byproducts. Small businesses are not required to submit these reports routinely. The Administrator will request toxicologic information available where the need is indicated.

Talk to a Knowbody. DISCOVER WHAT'S NEW IN BETTER PERFORMING FURNACE TUBES

Pull boring and new generation alloys increase furnace efficiency for greater production and reduced cost.

- With pull boring you can convert from as-cast wall sections to thinner, fully sound wall tubes. Thinner walls mean lower tube skin temperatures and lower thermal stresses. Improved thermal efficiency means increased production at the same firing temperature.
- Additional production benefits are also available from higher hot-strength alloys: HP, 25-35W and 30-50W. Other special alloys are available for manifolds, transfer lines and piping applications.

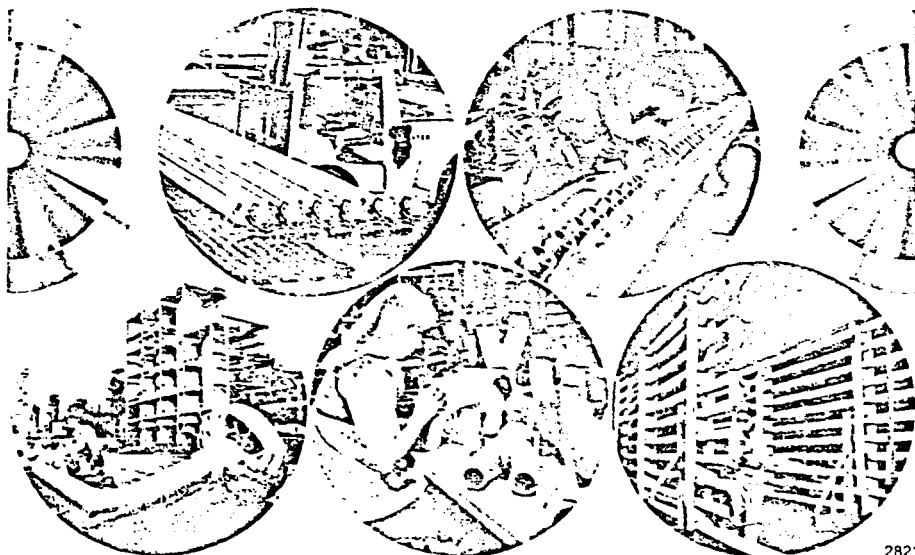
WCI provides you with the knowhow in metallurgy, fabrication, quality control, centrifugal casting, **plus investment cast U bends and fittings.**



The complete knowplace for your furnace tube requirements.

Wisconsin Centrifugal

Waukesha, Wisconsin 53186 (414) 544-7700



Circle 248 on Reader Service Card

Two more requirements: Manufacturers are required to retain records of significant adverse effects to health or the environment. They must inform EPA on obtaining information regarding a substantial risk caused by a chemical.

- Chemical Substances List. The Administrator will compile a list of substances which he has found present or may present an unreasonable risk of injury to health or the environment. Prior to manufacture of a substance on that list one must present data believed to show that such substance will not present an unreasonable risk of injury.

- Priority List. There is to be a priority committee with one representative from each of eight governmental and scientific agencies. It will develop a priority list for testing of no more than 50 chemical substances or mixtures. This list is to be published. The Administrator is not compelled to follow the list exactly. But, if he departs from it, he must publish his reasons.

- Testing. The Act establishes procedures by which existing and new materials are to be tested for hazards to man and the environment. The Administrator may prescribe testing for: Cumulative or synergistic effects, cancer, gene mutation, birth defects and behavioral disorders.

A major problem is how to test the hazards to man. In most areas, we cannot experiment with man, only with animals. We know that different animals sometimes respond differently to a chemical. So infrequently cancers arise in mice, but not in other species. In many situations, not all of the people exposed develop cancer.

Until we understand these differences more completely, we have to be cautious. Scientists in government, universities and industry are working to increase our ability to assess the hazards of chemicals to man.

Each company involved with a chemical is responsible for the tests. Where more than one company is involved they may designate a single party to perform the tests and share the costs. As I mentioned earlier, this cooperation is already going on.

Because of the limitations of testing facilities and qualified people, especially toxicologists, we cannot tolerate unwarranted duplication in testing. There are about 500-700 identified

002231

TOXIC SUBSTANCES CONTROL IS HERE

toxicologists in the U.S. Competition for their services by new and expanding laboratories is very strong. The universities are turning out only about 150 per year.

• **Regulation.** If the Administrator finds that there is a reasonable basis to conclude that the manufacture, processing, distribution in commerce, use or disposal of a chemical substance or mixture may present unreasonable risk to health or the en-

vironment, he shall *by rule* apply among others the *least burdensome* of the following corrections:

1. Label with adequate warnings
2. Limit the concentration of material for a particular use
3. Limit the amount which may be manufactured, processed or distributed for a particular use
4. Prohibit manufacture, processing or distribution for a particular use
5. Prohibit manufacture, processing or distribution.

In developing regulation, the Administrator shall consider the risks, benefits, economic consequences and the impact on small business.

• **Sew substances.** A manufacturer who intends to produce a new chemical substance not on the inventory must submit a notice to the Administrator at least 90 days before manufacture. Even if the substance is on the inventory, such notice must be given by a manufacturer or processor if the intended use of the substance is significantly different from past use.

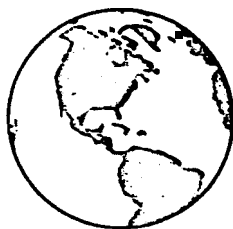
All notices shall give the trade name and chemical identity of the product, the amounts manufactured and proposed to be manufactured, the proposed categories of product uses, description of byproducts, existing data pertinent to health and environmental effects related to the product, the estimated number of employees that will be exposed to the product (and the duration of that exposure) and the anticipated manner of disposal of the product.

• **EPA Authority to Make Rules Effective Immediately.** If there is *insufficient* information to evaluate health or environmental effects, the EPA may propose a ban. If the manufacturer objects, EPA must go to court to halt manufacture. Where there is *adequate* information to indicate that the substance presents an unreasonable risk, EPA must go to court to halt manufacture or prohibit specific sole use. But it may make immediately effective rules to restrict use, require labeling or impose other lesser restrictions while formal rule-making is proceeding if it determines that continued manufacture would present serious or widespread injury or damage to health.

• **Effect on State Law.** The Administrator may, on application, permit a state or local government to have a rule for testing or a regulation if compliance does not cause violation of this Act and if the state's requirement provides *+* significantly higher degree of protection and does not unduly burden interstate commerce.

States and local governments may prohibit the use of a substance or mixture (other than in manufacture or processing).

• **Imports.** Chemical substances or mixtures shall be refused entry into the United States if they fail to conform with any rule in effect under



*engineering
construction
management*

FENIX & SCISSON, INC.

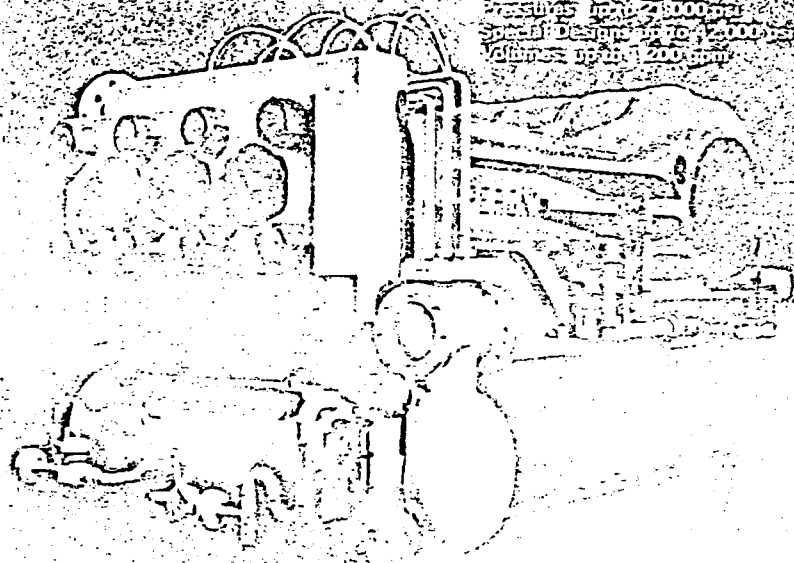
5805 E. 15th St. / P.O. Box 15609 / Tulsa, Okla. 74112
918 / 835-9471

PERONI PUMPS

HIGH PRESSURE PLUNGER PUMPS

= acids, ammonia, carbonate, slurries, etc.

Pressures up to 20,000 psi
Special Designs up to 42,000 psi
Flows up to 1200 gpm



GESSCO SALES
div of
Gulf Engineering Co. Inc.

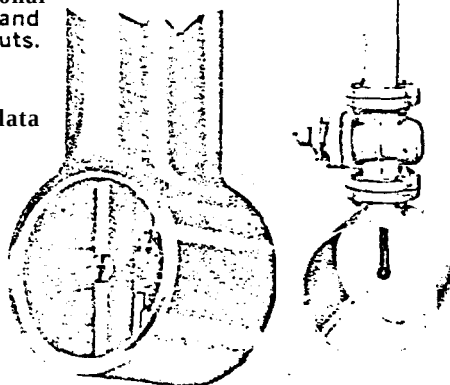
P.O. Box 15702
New Orleans, La. 70175
Telephone: (504) 885-7525
Telex: 587569 GULFEN NO 10 N

Circle 253 on Reader Service Card

NOW...a retractable

TURBO-PROBE®

- For low-cost, easily installed flow measurement in pipes to 6 ft. in dia.
- Can be inserted or withdrawn under line pressures to 10,000 PSI.
- Turbine rate directly proportional to velocity of fluid.
- Well-suited for use with conventional flow-rate indicators, controllers, and totalizers which accept pulse inputs.
- Easily interfaces with systems providing temperature and/or pressure corrections to convert data to standard conditions.
- Shrouded rotor.
- Non-rotating stem to provide precise and repeatable alignment in line.
- Call sales for details NOW!



Model TR-3



THE flowmeter company

Flow Technology Inc.

4250 E. BROADWAY RD., PHOENIX, AZ 85040 • PH 602 268-9776 TELEX 588-344

Circle 254 on Reader Service Card

TOXIC SUBSTANCES CONTROL

this Act. This is designed to protect both the consumer and the producer.

What HPI must do. I will now discuss five things your company may do to comply with the Act.

1. **Follow Federal Register.** The *Federal Register* is the one place where all announcements of agency actions are published. Many companies provide one individual with a list of their products and concerns. He has the responsibility of reading the *Register* and keeping them advised. Where size does not permit, a next alternate is to look to a trade association such as the MCA or others for alerting on regulatory developments.

2. **Work with Trade Association.** Two or more companies producing or using a particular compound will need to work together to develop information about the hazards, the costs of various means of regulation and to present a consensus view to the EPA. This can best be done within a trade association to avoid duplication, spread the cost and minimize the concern for antitrust violations. Increase of trade association activity of this sort is inevitable.

3. **Compounds on Inventory List.** You will need a list of all the products you use, produce and discard. See that your products are on the EPA list of existing substances. If you have a chemical intermediate which does not get out of the plant, you may wish to apply for an exemption.

4. **Testing.** You will want to be sure that any material on your list presenting an unreasonable risk has been adequately tested. You should be able to obtain information on testing of raw materials from your suppliers. For testing commodity products, work with other companies under a trade association.

For proprietary products, for which you are the only manufacturer, you will probably want to develop your own priority list to decide which compounds to test first. Input from toxicologists, manufacturing, business centers, experts in governmental regulations will be important in these decisions.

5. **Reporting.** A great many procedural details for reporting are yet to be developed by the Office of

002233

Circle 255 on Reader Service Card →

Pilot 15 years!

Fifteen years ago PILOT was an idea today PILOT is a reality. The APi sponsored series of training programs teaches trainers and processors around the world with 1981 tests of effective operator training.

What makes PILOT so successful?

Content APi specialists define and develop each program. Learning that PILOT is a practical rather than a theoretical training program. The primary personnel are used in tests for accuracy and training.

Method By using the programmed learning format PILOT training is designed to help a learner to move at his own pace developing confidence in his own learning.

Value Because PILOT programs are developed for industry but are they can be sold at prices even a tight training budget can appreciate.

PILOT is developed for the APi by Howell Training, a leader in the industrial training field. If you aren't using PILOT, it is time to get it. Use any PILOT program in your facility. Write us for our current price list or for a complete PILOT information packet.

Become part of the PILOT success story.



HOWELL TRAINING
2440 NORTH LOOP WEST
SUITE 204
HOUSTON, TEXAS 77018
(713) 688-9537

Circle 256 on Reader Service Card

TOXIC SUBSTANCES CONTROL IS HERE

Toxic Substances. Nonetheless, for an undetermined number of chemicals, you will be expected to report the volume of production, categories of uses, chemical identity, impurities, byproducts, disposal materials and the number of people exposed.

You may have to submit a list of all toxicologic information available on particular compounds and later on the reports themselves.

You will be expected to keep records of and report on significant adverse effects to health or the environment and information acquired regarding a substantial risk caused by a chemical. For future epidemiologic studies you will need readily accessible records i.e. computerized records of exposure, illness and cause of death.

ACT'S ECONOMIC IMPACT

From a documented study of the economic impact of a Toxic Substances Bill, MCA estimates the cost of the bill to the Chemical and Allied Products Industry at \$260 million to \$1.3 billion (Table 2). This is not the total cost in the United States but only for the chemical and allied products industry.

Unknowns. There are two major unknowns in assessing the economic impact of this legislation. The first of these is the judgment and policies of the Administrator. Of necessity, much is left to his discretion. He has a highly complex subject and not enough information to make critical decisions objectively. He is faced with tremendous political pressures from environmentalists, activists and industrialists. EPA Administrator, Russell E. Train, has promised a "go-slow" approach. This is yet to be demonstrated. What will his successor be like?

A second major unknown is industry's response to the regulations. The two columns in Table 2 reflect two ranges for these interactions. The column on the right is based on the suppositions that with an aggressive Administrator there will be comprehensive premarket screening of all major new substances and applications, with selective screening of minor ones, and that industry will increase expenditure on research by \$600 million to maintain the development of new products at a steady rate.

The column on the left is based on

TABLE 2—Economic impact

Start-up Costs		115	
Annual Expense		\$ Million	
Administration.....	64	82	
Extra R & D to maintain same So. new compounds.....	29	600	
Testing of existing substances.....	50	40	
Premarket screening.....	24	252	
Delays (time costs after completed R & D).....	22	86	
Product labeling, quality control monitoring.....	4	51	
Application/legal fees.....	193	1130	
Extra ordinary cost limiting and banning.....	165	195	
Total continuing cost.....	358	1325	

the suppositions that the Administrator will be more selective in requiring testing and that industry will reduce the level of R&D by 15 percent to pay for the costs of compliance and that this will result in a 40 percent reduction in the number of new products to be tested.

Annual expense. The figures of \$29-\$40 million in Table 2 represent testing for some 65-100 existing compounds/yr. respectively. Industry will be testing compounds beyond the 50 established in the priority list.

Premarket Screening was projected to require testing of some 1,200-6,500 new or modified products and significant new applications of older products and to cost some \$50-\$250 million. Sfr. Schweitzer now projects testing for only 200 new products and uses. Adding this to testing on existing products gives a total of \$80-\$290 million per year as added direct costs for toxicologic and environmental testing.

Fees not to exceed \$2,500 for large companies and \$100 for small ones are charged for submitting test data under the legislation. Litigation is assumed to occur in 10 percent of the cases.

In spite of efforts to minimize costs to small businesses, there will be pressures on small volume products because of the difficulty in spreading the costs of testing and compliance. Because of this, there will be pressure for removal of lower volume products from the market, and reluctance or refusal to consider new ventures unless truly large-scale and continuing production appear highly probable. Of the pesticides coming up for registration, 30 percent are being dropped.

Continued

002234

Circle 257 on Reader Service Card—>

OFFICE OF TOXIC SUBSTANCES

The Office of Toxic Substances (OTS) was set up within the EPA in 1973 when passage of a bill was expected (Table 3). There is currently great confusion in the OTS due to a major reorganization.

Key personnel. Glen Schweitzer is giving personal attention to a group of people with new assignments for implementation of the Act.

Ken Olsen has been brought in from the Office of Pesticides to handle any communication with the public concerning toxic substances.

The OTS is preparing a PERT chart of future activities and has issued a summary of the ACT. The publication in the Federal Register is due no later than July 1 on proposed rules for inventor). reporting. Publication of the final inventory report and Priority Committee is due no later than November 1977.

Dr. Wallen, Deputy Director, will be managing continuing line activities such as *Early Warning* to anticipate

TABLE 3 — Office of toxic substances

Glenn Schweitzer, Director	Dr. I. Eugene Wallen, Deputy Director
Currently total staff 45	14 Professionals \$5 MM Yr.
After TSA 150	12 MM/Yr.
Spent \$20 MM—1973-76	
Data collection evaluation by hire	
30,000 Industrial chemicals, 2 million mixtures	
1,000 New chemicals each year	

the next hazard before it breaks as a crisis.

Much work ahead. There is a tremendous amount of work to be done. Forms for reporting the amount of different chemicals produced, their compositions, uses: impurities and by-products will need to be prepared. Categories of chemicals and of uses for the whole of the chemical industry will have to be defined: something like higher aliphatic alcohols to cover C₁₀ and higher alcohols rather than listing each individual alcohol. It is the expressed intent of the OTS that the category of polypropylene will cover materials of different molecular weights, blends with other polymers, dyes, inhibitors, etc. This is very im-

portant. It means that variations in these factors can be carried out without having to go through premarket notification. Questions remain as to how to handle and protect confidential information.

The Office now has a total staff of 45 people with 14 professionals and has been operating with a budget of \$6 million/yr. Now that the Toxic Substances Control Act has passed, the staff will be expanded to 150 people and a budget over the next three years of \$10 million, \$13 million and \$16 million/yr. Much of the responsibility of the OTS will be contracted to outside offices and laboratories.

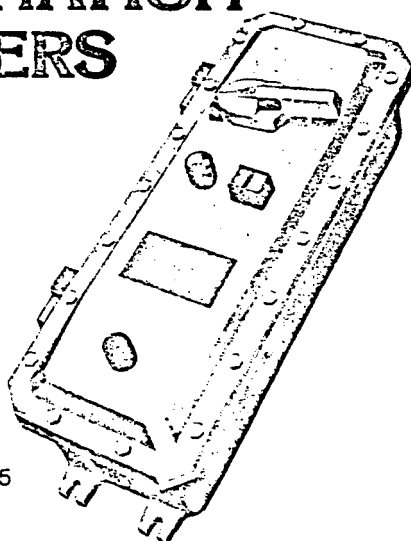
MCA ADVISORY COMMITTEE

In industry, the Manufacturing Chemists Association (MCA) has created a new committee—The Chemical Regulations Advisory Committee to serve as a focal point for dealing with matters developing from toxic substances legislation (Table 4). They will be working closely with the EPA and Office of Toxic Substances.

A first activity joint with the OTS

ADALET EXPLOSION-PROOF COMBINATION STARTERS

Size "0" thru "5"
Class I
Groups B, C & D



Ask for Bulletin 1175

For original thinking..

ADALET DIVISION

4801 WEST 150TH STREET, CLEVELAND, OHIO 44135

A SCOTT & FETZER COMPANY

Circle 258 on Reader Service Card

SAFETY even high atop a STACK PLATFORM



United structural grating with unique Anti-Skid is the safest surface for surest footing even wet, oily or covered with ice and snow

Inside on a floor or mezzanine or outside on an EPA inspection deck, United friction-lock grating installs faster and gives the best coefficient of friction available. TWO widths—TWO heights—choice of gage and length. Slotted-Grip—a safe surface available without Anti-Skid shoe-grippers.

Write for FREE catalog & samples.

**United
interlock
grating**

P.O. Box 520, Columbus, Ohio 43216, 614/436-1111
Circle 259 on Reader Service Card

002235

Circle 260 on Reader Service Card

TABLE 4—Manufacturing chemists association, chemical regulations advisory committee

Chairman	C. Dominguez	V. Chairman	M. Tietze
Secretary	C. Ingle		
(MCA Representative)			
Regulations	F. Hoerger		
Toxicology	J. M. C. Donough		
Technical affairs	C. Smith		
Legal affairs	T. Hanavan		
Liaison	C. Banks		

will be a series of meetings in New York, St. Louis, San Francisco, Chicago and Houston to inform industry as to what will be needed to comply with the Act.

TSCA goals. In review, the major impacts of the TSCA are:

1. Insure adequate testing of existing and new materials which present an unreasonable risk to health and the environment. This means testing about 65 existing and 1,000 new materials per year at a cost of about \$80 million/yr. This will require a significant increase in laboratory facilities and in training of toxicologists. Many small volume products will be withdrawn from the market. The cost of testing

and compliance will exert critical pressure on small scale manufacturers of proprietary products, and other information.

2. Besides the testing, industry will be required to record and report exposure data: toxicologic information, volumes of production, uses, byproducts.



About the author
CURTIS W. SMITH is a chemist on special assignment in R & D PRODUCTS, with Shell Oil Co., Houston. In research work with the company since 1955, he holds a

Ph.D. degree in organic chemistry from the University of Illinois. Dr. Smith is author of a book on acrolein, holds more than 75 patents and has served as manager of R & D for the former Industrial Chemical Division of Shell Chemical. He is deeply involved in the company's plans for reaction to safety and health legislative acts and standards, and also works with major industry organizations and societies which are active in coping with health/safety/environmental problems.

3. EPA will regulate testing, use, labeling, manufacture, distribution and disposal.

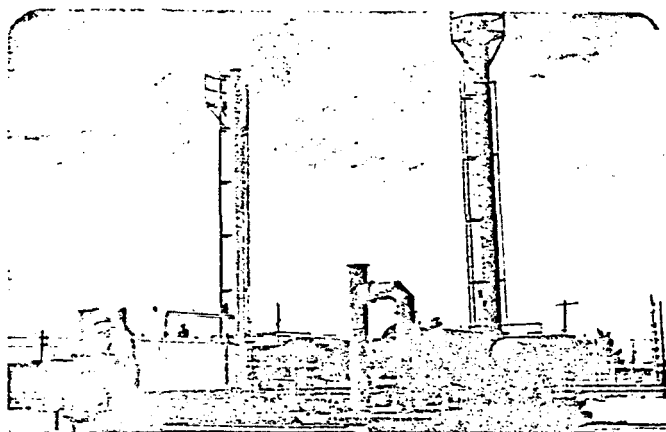
4. The MCA will provide a focus for responding to the EPX.

Looking ahead. In conclusion, the current Act represents significant progress over many of the areas of previous bills which troubled industry the most. It has: greater procedural safeguards than in earlier versions, a requirement that EPA must get a court order before it can ban the manufacture of a new chemical, improved definitions and procedures for regulating mixtures and new chemicals which will reduce the scope and burden of the Act, graduated regulatory steps, the absence of quotas and reduced reporting burdens on small companies.

We now face the task of making the industry's expertise available to the government so that the new law can be implemented in a reasonable and prudent manner.

ACKNOWLEDGMENT

The author is grateful to Dr. R. F. Glasser for Figs. 1 and 2 and for many helpful discussions.



Pre-engineered, packaged, and skid-mounted for fast field hook-up, these proven amine gas-treating plants are stocked in common sizes. Available from 5-to-140 GPM capacities, larger on request. Dehydration and sulfur-removal equipment also available. Excellent way to save time and headaches . . . usually at a cost below the norm. Phone inquiries welcome, or write for free literature.

Send
for
UAP
handbook

Pressure
vessel seals

for boilers, heat exchangers, turbines,
compressors

UAP Metallic O-rings form reliable static seals in metal-to-metal applications. Fabricated from stainless steel or Inconel, they offer optimum strength and spring-back to maintain a seal through fluctuations in extreme temperatures and pressures. They can meet specifications for virtually every component in the power or chemical process plant and refinery including fire test requirements to 1800° F. Tubular or solid types range up to 25 feet or more diameter, or as small as .250 inch OD. Write for Handbook or call (513) 223-3525. United Aircraft Products, Inc. Box 1335, Dayton, Ohio 45401.

UAP
SEALS DIVISION