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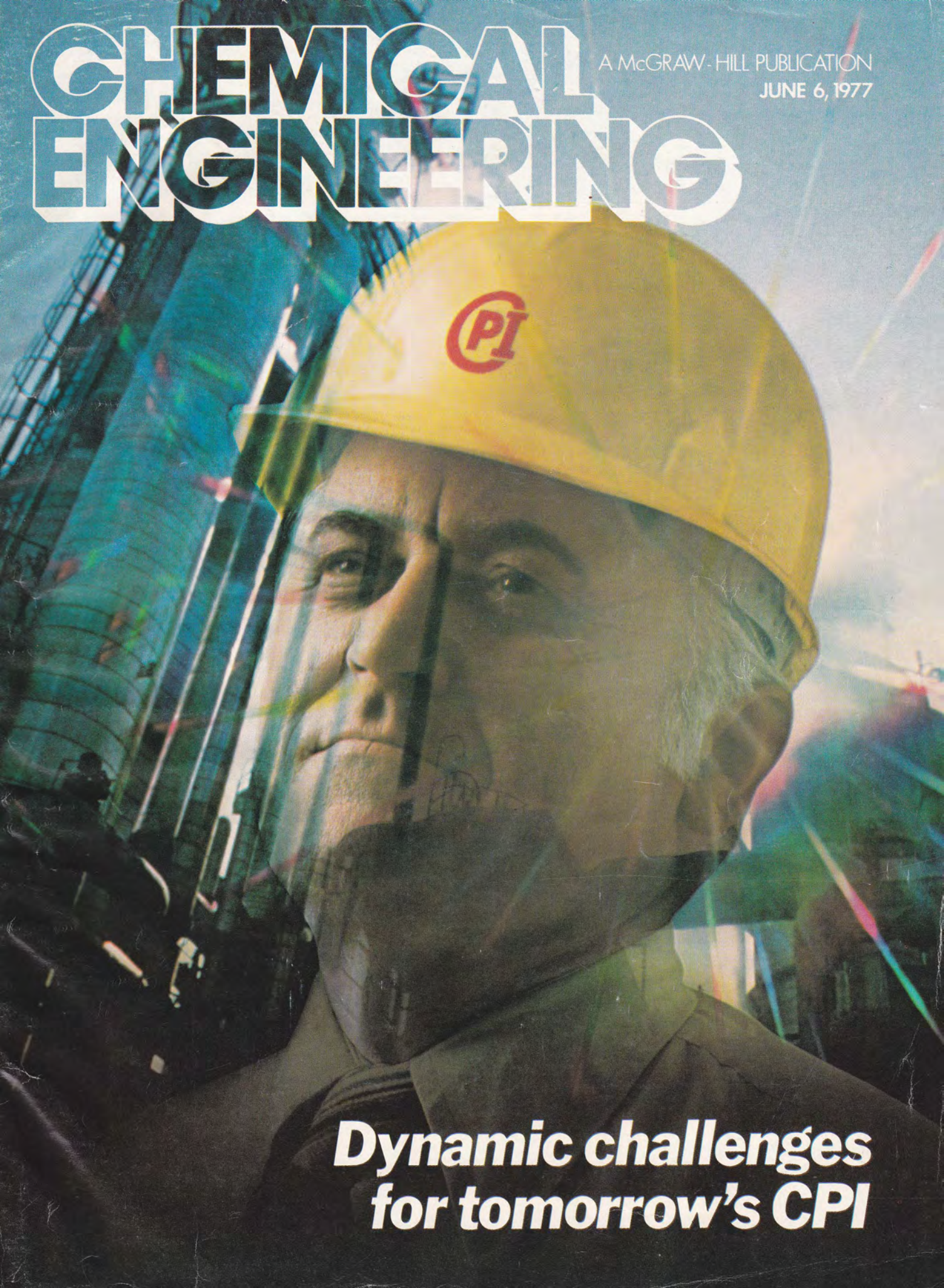

Dynamic challenges for tomorrow's CPI

OSHA, EPA and plant design

Designers of chemical-process plants cannot ignore governmental regulation. Though regulation shows up at virtually all levels of government, and is pervasive throughout the world, U.S. engineers find themselves much involved with the federal Occupational Safety and Health Administration and the Environmental Protection Agency, in particular.

Frank W. Buehner, *Arthur G. McKee & Co.*

☐ Regardless of job function, chemical engineers increasingly find it necessary to be versed in government regulation of worker safety and health and in environmental protection. This need is especially great for engineers in design-related functions, such as capital-cost estimating, process and equipment design, and plant layout.

Particularly important is the sheer ability to learn what is legally required—by the U.S. Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), and by corresponding regulatory groups at the state and local level, in the case of plants built in the U.S., and by the appropriate regulatory bodies in other countries, in the case of plants built abroad.

Indeed, unprepared designers can find themselves swamped in legal paperwork. Consider U.S. federal regulation alone: In 1976, over 56,000 pages of Rules, Regulations and Notices were printed in the *Federal Register* (FR)[*1*], and dispersed throughout this were the myriad statements pertaining to safety, health and environment. Legally, the material printed in the FR is prima facie evidence of the text of original documents; in blunter terms, it is the law. And, of course, this material does not take in voluminous regulation at the state and local level.

Organizing for compliance

Company size and function determine the actual amount of involvement the individual designer has in regulated functions; but, as a minimum, every designer of U.S. plants should understand how the federal regulatory system issues and updates its standards.

Small companies will, of course, place more regulatory responsibility on the individual engineer. Aids that editorialize on enacted and proposed regulations can help such an engineer. The Bureau of National Affairs' *Occupational Safety and Health Reporter* [*2*], for example, includes court cases and Notices of Contest that show the designer what safety-or-health violations are presently occurring. The relevant paragraphs in the regulations are also cited.

As for large corporations involved in many OSHA- and EPA-regulated functions, compliance requires an organized system to eliminate duplication of activities and ensure that updated standards are reviewed and routed to

the proper managers and design engineers. The logical starting point for such a system is the company library. The librarians' duties should include scanning the FR for pertinent regulations related to company operations and routing them to the regulatory analysts (see below), as well as obtaining sample copies of new updating-service publications for examination by designers. Librarians can be trained in the U.S. federal-regulations system through educational courses offered by the Office of the *Federal Register*. Apart from this, they must possess a thorough awareness of company operations.

Next are the regulatory analysts. Their function is to interpret standards and, for design projects, establish checklists of standards applicable to the job, in conjunction with the project manager. The checklists should be kept on file, and OSHA checklists passed on to the client for use when inspections occur. The regulatory analysts, usually a group of engineers and/or attorneys, must also ensure that company specifications reflect updated OSHA and EPA requirements.

In a large corporation containing such a regulatory system, the individual engineer-designer may perform fewer regulatory interpretations and thus become complacent. But the liability of the design professional has not yet been established as regards OSHA and EPA regulatory malpractice. Future court decisions could place legal responsibility on design professionals for omissions and errors related to OSHA and EPA regulations.

In-house data requirements

Regardless of size, companies should receive and maintain not only the FR but also the *Code of Federal Regulations* (CFR) [*3*], plus indexes. All of these are described in Table I. The need to maintain updated state and local codes will vary from company to company, but ultimately they will be required when intrastate work is performed. States' approved and implemented safety/health and environmental plans override federal OSHA and EPA requirements, but state plans are also being rescinded by the federal government. Updating services can keep one abreast of states' problems in implementing their plans.

Every design engineer must be sure that a standard being used has not been revised (perhaps completely rewritten) or deleted. Engineers who copy a standard once and continue to use it place themselves and their companies in jeopardy of an error. The FR is published daily and, theoretically, codes can be revised that often.

To be sure a regulation is up to date, it must first be located in the most recent edition of the CFR and coded in its arrangement (see Table I, under *Federal Register*). Next, the *Cumulative List of CFR Sections Affected* must be consulted for actions taken since the issue date of the CFR used. If action has been taken, the *Cumulative List* will indicate the proper page in the FR that contains the revision, addition or deletion. At this point, the engineer's review is current through the month of the *Cumulative List* employed. Finally, the FR contains a guide to a list of parts for each title of the CFR affected in that day's issue, and a cumulative list of parts affected by documents published to that date. Since the *Cumulative List of CFR Sections Affected* is published at the end of the month, the cumulative list of parts affected in each FR must be consulted for mid-month revisions.

Staying abreast of OSHA and EPA regulations (and their counterparts elsewhere) is not an end in itself, but a necesssary adjunct for legally acceptable plant design. What follows are some OSHA- and EPA-related considerations that the designer should keep in mind.

Designing for OSHA requirements

The expressed purpose of the Occupational Safety and Health Act of 1970 is "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources. . . ." [*3*] The Act of 1970 presently affects more than 5 million workplaces and 60 million employees. More than 400 amendments to it have been introduced in the last five years [*4*]. The most recent printing of OSHA standards—Title 29, Chapter XVII, Part 1910 of the CFR (called 29CFR1910)—was July 1, 1976.

A designer who begins to investigate OSHA standards will quickly become aware of many problems:

1. The standards do not allow for alternate design methods that provide equivalent worker protection. Even though many compliance officers acknowledge that certain equivalent designs meet the intent of the Act, other officers may cite the company and force it to seek a variance.
2. Some sections are very specific, while others are vague.
3. Some sections refer to another set of codes, such as ASME and ANSI. Effective dates of the referenced codes and current revisions of those codes must be investigated.

Where to get help

When a designer cannot get a satisfactory interpretation of a regulation from the standards, the area or regional OSHA office can be telephoned and an interpretation requested. OSHA has promoted the use of its offices as information centers, and it is poor practice to ignore this source of information. The designer should obtain the name of the officer actually consulted, and follow up on the request and interpretation in writing. OSHA will comment on alternate design methods, but the implementation of these should be used with reservation and with the consent of the owner.

Some 24 states have approved plans comparable to that of the federal government. An inquiry to an appropriate OSHA area office will confirm the status of programs of states in the vicinity.

Updating services are helpful design aids. They are available on a trial basis, or sample copies can be obtained [*2,5,6,7,8*]. Information concerning international health and safety standards is available from The World Health Organization [*9*]. Several countries have developed plans similar to those in the U.S. but, again, revisions are constantly occurring.

Most-active standards

Due mainly to impetus from organized labor, OSHA has increased its issuing of standards related to worker health. This is particularly reflected in *Toxic and Hazardous Substances*, Title 29, Chapter XVII, Part 1910, Subpart Z (29CFR1910.1000 to End) and *Occupational Noise Exposure* (29CFR1910.95). Standards in the safety area that are most cited by OSHA are the *National Electrical Code*

Federal repositories of federal regulations **Table I**

1. *Federal Register* (FR)—Published daily, Monday through Friday, excepting federal holidays. Cost, $50/year. Provides regulations and legal notices issued by federal agencies. The *Federal Register* is arranged in the same manner as the CFR (see below), as follows:
   a. Title—Each title represents a broad area that is subject to federal regulations. There are a total of 50 titles. For example, Title 29 involves labor, and Title 40 is about protection of the environment.
   b. Chapter—Each chapter is usually assigned to a single issuing agency. For example, Title 29, Chapter XVII, is about the Occupational Safety and Health Administration; Title 40, Chapter I, is about the Environmental Protection Agency. Chapters are sometimes divided into subchapters. For example, Title 40, Chapter I, Subchapter C, is about air programs; Subchapter D, water programs.
   c. Part—Chapters or subchapters are divided into parts, each consisting of a unified body of regulations devoted to a specific subject. For example, Title 40, Chapter I, Subchapter C, Part 50, is National Primary and Secondary Ambient Air Quality Standards. Title 29, Chapter XVII, Part 1910, is Occupational Safety and Health Standards. Parts can further be divided into subparts, relating sections within a part.
   d. Section—The section is the basic unit of the CFR (see below), and ideally consists of a short, simple presentation of one proposition.
   e. Paragraph—When internal division of a section is necessary, sections are divided into paragraphs (which may even be further subdivided).
2. *FR Index*—Published monthly, quarterly and annually; cost included with that of *Federal Register*. The index is based on a consolidation of contents entries appearing in the month's issues of the *Federal Register* together with broad subject references. The quarterly and annual index consolidates the previous three months' and 12 months' issues, respectively.
3. *Code of Federal Regulations* (CFR)—Published quarterly and revised annually. A codification in book form of the general and permanent rules published in the *Federal Register* by the executive departments and agencies of the federal government.
4. *CFR General Index*—Revised annually, July 1, cost included with that of CFR. Contains broad subject and title references.
5. *Cumulative List of CFR Sections Affected*—Published monthly and revised annually according to the following schedule: Titles 1—16 as of Jan. 1; 17—27 as of April 1; 28—41 as of July 1; 42—50 as of Oct. 1. The CFR is also revised according to these dates. Cost included with that of *Federal Register*. Provides users of the CFR with amendatory actions published in the *Federal Register*.

(29CFR1910.309) and *Machinery and Machinery Guarding* (29CFR1910.211 to End).

The first of those four concerns the normal release of toxic and carcinogenic substances, carried via vapors, fumes, dusts fibers or other media. The Act requires the designer to make calculations of personal exposure, considering both concentration and exposure time, taking into account normal operational releases, losses from pump and agitator seals and from control-valve packings, and similar sources. The designer can typically forestall overexposure by specifying special valves, seals, vapor-recovery systems and appropriate ventilation systems.

The widespread use of chemical tradenames, and the reluctance of many chemical or materials-of-construction suppliers to identify their products by chemical composition, pose significant problems to the designer attempting to determine worker exposures. As a possible solution, the engineer can submit the table of hazardous materials to the supplier, and request that a material with safe exposure time be chosen for design purposes.

The list of hazardous materials is increasing at a rapid rate. So are revisions of present material exposure times and concentrations. The FR should be examined closely for proposed and new regulations before beginning the detail design phase of a project. A new publication, *Chemical Regulation Reporter* [*10*], to aid the design engineer began in March 1977. This weekly information service includes subject matter concerning the Toxic Substances Control Act (a relatively new law that is administered by EPA rather than OSHA).

Noise control

One of the shortest and seemingly most innocuous standards in OSHA is 1910.95—"Occupational Noise Exposure." Contrary to this appearance, however, industrial noise control is among the most complex and controversial issues contained in the Act. Noise violations for general industry totaled nearly 8,000 from July 1972 to December 1975 [*11*].

The designer should closely monitor the present 90-dBA rule, because an 85-dBA revision is being considered. Much of the delay in issuing a revised standard is due to the economic impact associated with it [*12*]. Meanwhile, a proposal to use personnel protective equipment (versus engineering controls) only as a last resort is being challenged by industries, which claim that programs employing ear protection have been effectively instituted in several areas [*13*]. This controversy is likely to continue, whatever the outcome of the revised standard.

Noise control in the design stage requires a well-planned, timely execution of steps to obtain the desired results as well as minimize interference and delay of the job. And since many communities have adopted EPA's recommended noise-level criteria, or have stringent plans of their own, design-stage noise control must also consider noise leaving the plant.

During plant design, it is a good idea to prepare two noise specifications to avoid confusion: one to define the designer's own scope of work, and the other to set vendor noise-level requirements for the various pieces of equipment.

A common misinterpretation of the noise standard is that the entire facility must be below 90 dBA. The

standard actually requires that the worker's eight-hour exposure meet the following criteria [8]:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} \cdots + \frac{C_n}{T_n} \leqslant 1 \qquad (1)$$

where:

C_n = Time of exposure at a specified noise level.

T_n = Total time of exposure permitted at that level.

Individual-worker exposure according to Eq. (1) for open-air plants is usually found by using a computer program that employs a noise-source data base and calculates the resultant noise level for the many equipment sources at intersections of a gridded plot-plan. Enclosed facilities require an approach similar to open-air plants but employing room-acoustics equations instead of those for outdoor noise propagation [14,15].

The use of contour programs or the manual connecting, on a diagram, of points having equal noise levels will produce a contour or an isopleth. With the inclusion of information from the plant owner concerning worker stations and routines, the designer can calculate the eight-hour exposure of each employee. Once this has been done for all employees, a data analysis procedure can pinpoint what equipment is responsible for employee overexposures according to Eq. (1). The analysis procedure includes varying the noise-source data for suspected equipment, and rerunning the program until all employees are within the criteria of Eq. (1).

The designer must exercise considerable judgment to establish final design-stage noise recommendations. These should not only take into account the results of the equipment-data-analysis procedure but also consider additional factors such as administrative controls, feasibility of redesign, economic alternatives, intrusion of noise into the community, and the basic limitations of the equations employed in the computer program.

The following recommendations can greatly aid the designer:

1. Visit the proposed plantsite whenever possible. Technical data tend to overlook many factors.

2. Obtain complete vendor noise-data sheets before the purchase order is let. If this is impossible because actual test data are required, the data sheets should be received before shipment.

3. Require that an ambient-noise survey be performed—preferably by a third party, to eliminate the possibility of a legal challenge that the data are biased. These data are required as the base of the plot-plan overlay noise contours and as a permanent record of the preconstruction levels. If the community reaction to the facility is expected to be negative, ambient surveys employing statistical methods [14] and carried out over a year's time may be advisable.

4. Establish a procedure to take into account piping sources in the noise contours. Control valves are major contributors to in-plant noise, and are considerably difficult to model [14].

5. Specify noise-criteria (NC) curves [16,17] when control rooms and offices are designed. The use of single-valued dBA sound levels or octave-band sound pressure-level requirements instead, for these areas, can fail to exclude objectionable narrow-band noise from air-conditioning systems.

The designer should use every opportunity to include noise studies in the design stage of any industrial facility. Acoustical problems that are instead left for field resolution cost roughly twice as much. Unnecessary costs incurred in post-construction noise work may include the replacement of insulation, redesign of piping configurations to accommodate silencers, modification of equipment, additional labor costs, and possible loss of plant on-time to make the necessary changes. What is more, it can be hard to identify particular noise sources in the normally diffuse acoustical field of an industrial facility. This often requires special vibration-measuring techniques or a partial shutdown of nearby equipment.

The National Electric Code

Even though the National Electric Code (NEC) is often cited by OSHA, electricity-related violations occur mainly during construction and in older facilities that are not in compliance with the Act.

Determining the proper codes is a major obstacle to overcome in design-stage engineering. And, unfortunately, many design specifications contain statements that are inconsistent: "Design in accordance with all OSHA standards and the most recent edition of NEC, ANSI, etc." The inconsistency can come about because OSHA does not immediately adopt the *most recent* NEC or other consensus standards, and because there are no guarantees that these will be strictly adopted when revised. Also, local inspectors may require actions that conflict with either OSHA or the most recent NEC. Thus, investigation and definition at the beginning of engineering will eliminate misunderstanding and ultimately save time and cost.

Machinery and machinery guarding

With regard to machinery and its guarding, a request for information on technical issues, and notices of public meetings, were issued on Jan. 7 in the FR, in accordance with results of a Presidential task force on revision of the OSHA safety regulations. Following completion of the meetings, and expiration of the comment period (Apr. 7), OSHA is reviewing the information and, if appropriate, will develop a proposal to amend the existing standard.

So, the designer should be aware that a revised standard on machinery and its guarding is likely. Designers should also examine the Jan. 7 FR for its OSHA comments.

Designing for EPA requirements

Unlike OSHA regulations, which are based mainly on industry standards employed for years by engineers, the standards that comprise Protection of the Environment (Title 40, Chapter I of the CFR), represent a new phenomenon to the designer. There is much confusion over intent and meaning of the laws, as well as over procedures and requirements needed to obtain mandatory permits.

Among the steps required for taking environment into consideration during a design project are these:

1. Develop a timetable for completion of required environmental statements or reports, and incorporate this timetable into the critical-path planning for the project.

2. Determine what environmental standards (including land-use laws and resource-recovery legislation) require compliance by the project.

Key aspects of U.S. federal environmental regulation (Based on Title 40 of the CFR) — Table II

Part	
	Title 40 — Protection of Environment
	Chapter I — Environmental Protection Agency
Part	**Subchapter A — General**
6	Preparation of Environmental Impact Statements (Information for the designer in preparing an EIA.)
	Subchapter C — Air Programs
50	National primary and secondary ambient air quality standards
53	Ambient air monitoring reference and equivalent methods
60	Standards of performance for new stationary sources
61	National emission standards for hazardous air pollutants
81	Air quality control regions, criteria, and control techniques
	Subchapter D — Water Programs
112	Oil pollution prevention
120	Water quality standards
122	Thermal discharges
128	Pretreatment standards
129	Toxic pollutant effluent standards
133	Secondary treatment information
	Subchapter E — Pesticide Programs
	Subchapter H — Ocean Dumping
	Subchapter N — Effluent Guidelines and Standards
	(Parts are not listed because this subchapter is presently being revised)
	Chapter IV — Low-Emission Vehicle Certification Board
	Chapter V — Council on Environmental Quality
Part	
1500	Preparation of Environmental Impact Statements: guidelines (Information for the designer in preparing an EIA.)

3. Obtain baseline information.

4. Examine all sources of information to aid in determining environmental safety, as well as economic and social feasibility.

5. Prepare effluent and emission summary, taking into account various alternates to meet requirements.

6. Consider possible environmental impacts for which a design to meet requirements does not exist.

7. Prepare environmental statement or report.

Environmental standards

Table II contains a checklist of environmental considerations from Title 40 of the CFR. Any expansion of this checklist must take account of the applicable state and local codes—in areas such as particulate emissions, these may be more stringent than the federal codes. Too many states single out and regulate specific industries.

Locations of planned project sites should be assessed to see if they come under any area or regional regulations. These codes were instituted to regulate pollution from facilities that are potential polluters of several states and/or communities. An example of regional regulators is The Delaware River Valley Authority.

Local codes can also seriously affect design parameters. For example, many municipalities have adopted the EPA document, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with Adequate Margin of Safety" [*18*]. Although this publication was intended to be a guideline only, many local codes are direct excerpts or relaxed versions.

EPA procedures

The National Environmental Policy Act (NEPA), signed into law January 1, 1970, requires that federal agencies prepare an Environmental Impact Statement (EIS) in advance of any major "action" that may significantly affect the quality of the environment. The federal agencies require a report, usually an Environmental Impact Assessment (EIA), for use in preparing the EIS.

Prior to an "action" such as issuing construction and operating permits, a draft EIS is prepared for review by other federal agencies and by state and local agencies, as well as by other interested parties. After comments are received and resolved, they are incorporated in the final EIS. Both the draft and final EIS are filed with the President's Council on Environmental Quality (CEQ) and are available for public inspection. EPA requires federal agencies to consider public opinion before an action.

An EIA is required to be a full-disclosure statement. This includes project parameters that will have positive environmental impact, negative impact, or no impact at all. The actual role that a design engineer will play in preparation of the EIA will depend upon the size of the project, as well as the division of work between client, contractor and environmental consultants.

In most cases, individual design engineers will only be involved in a specialized area of EIA preparation, in accordance with their expertise. However, each engineer should be aware of the total scope of work necessary to prepare the EIA, as well as the division of work. This will eliminate costly duplication of activities, as well as provide the opportunity to furnish important design alternates.

A wealth of data may be available to aid the designer in performing an EIA study, because other recently completed construction in the area, including highways, requires an approved EIS and this is available for public inspection.

Selecting alternate sites

Picking a plantsite involves many considerations besides environmental ones. However, one important decision from management that will aid the designer and owner is the number of alternate sites to be compared if environmental or public opposition creates an unfeasible condition. Neglecting specific exceptions (which can approach $4 million [*20*]), the cost per site for preparing an EIA may range from $50,000 for small projects to $1.5 million for a large petroleum refinery [*21*]. The number of selected sites to be examined must, of course, be based on

the amount of funds available. But a comparison of alternate sites can provide benefits:

1. The comparison will compel a complete listing of all the necessary regulations, and will minimize possible deletions of important standards. Thus, environmental costs associated with studies, engineering and required equipment will be estimated more accurately.

2. The study will point out highly restrictive standards or inadvertent regulatory-agency omissions, which could otherwise have serious economic impact on design.

3. The study could rule out possible sites, due to highly restrictive standards.

Emisssions and effluents study

Since it may take a full year to obtain baseline data such as air quality, water quality, ambient noise levels, ecological surveys and social surveys [*19*], emissions and effluents studies should take place concurrently to avoid delay in preparing the EIA. In many cases, an environmental consultant will be gathering the baseline data, and an arrangement for conveying this information promptly to the designer should be established.

The effluents and emissions study must include *all* "significant" sources of pollution. The omission of data could cause inconsistencies that could surface at an inopportune time. Negotiations are involved in issuing permits, and the regulatory agencies are aware of problem areas in meeting difficult codes.

Getting environmental help

So as to minimize hurried and excessive searches for literature about new design applications and important trends in standards, updating services and industrial newsletters are available [*22, 23, 24, 25, 26*].

Information on foreign standards [*27*] is available from sources such as the *International Environmental Guide* [*28*]. International environmental standards fluctuate, and should be obtained a minimum of six months before required for information purposes, to avoid delays.

Help from EPA itself is available [*29*]. A listing of EPA regional offices appears in the CHEMICAL ENGINEERING Deskbook issue, Oct. 18, 1976, p. 21. However, contacts should be authorized by the company's environmental supervisor and/or regulatory analyst since complexities involved in interpretation of standards will usually force EPA to be overly conservative with its reply.

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The author

Frank W. Buehner is a Senior Environmental Engineer for Arthur G. McKee & Co., Cleveland, OH 44131. His duties have included safety, health and environmental engineering for McKee's worldwide operations. Holder of B.S. and M.S. degrees in chemical engineering from Cleveland State University, he is a member of AIChE, and an associate member of The Acoustical Soc. of America.