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Fire protection (p. 74)

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TOMORROW'S VALVE UNIVERSE

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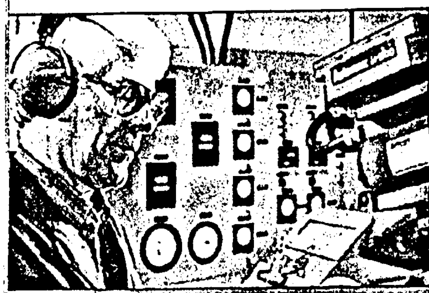
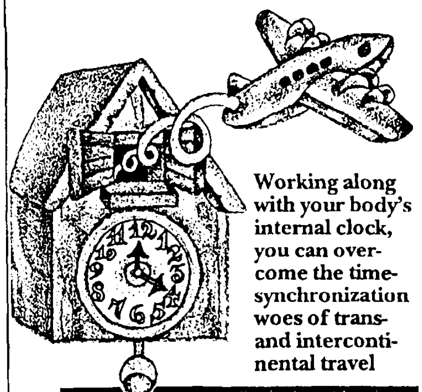
A filter, as shown at right, can characterize the size range of particulate matter that must be captured by air-pollution control equipment

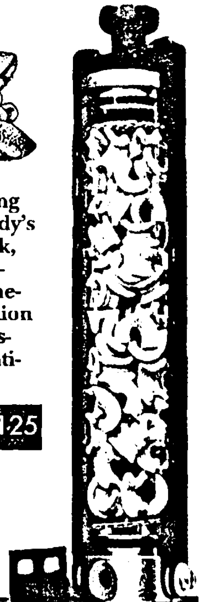


Manufacturers and vendors can't just offer wares. They must be on the cutting edge in design, and must test and optimize products to meet customer needs

Sampling of hazardous materials by means of an automated, enclosed sampler will eliminate exposure of workers



Working along with your body's internal clock, you can overcome the time-synchronization woes of trans- and intercontinental travel



All kinds of equipment, from scrubbers to filters, are going portable, to control air pollution in remote locations

Technology is enabling separation of chiral chemicals —stereoisomers with identical chemical formulas arranged as mirror images of each other, but having different properties

Optimization packages can make improvements in plant operating efficiency

Chemputers V will be part of our first-ever CE Expo, to be held at the George R. Brown Convention Center in Houston, June 3-4. Plan now to attend

Cover art: SALEM KRIEGER

Emulsions in wastewater pose a vexing problem for facilities attempting to recycle water and stay in compliance with permissible discharge limits. But the challenges are no less formidable for routine maintenance. The removal of emulsions, a major constituent of which are fats, oils and greases (FOGs), is necessary to prevent them from depositing on pipes and fouling filtration media.

Not even facilities that use crossflow membranes are exempt from the problems caused by emulsions. While oil[illegible] may be eliminated, the concentrate that accumulates during processing remains to be dealt with. The concentrate coats evaporator heating elements, requiring frequent cleanup and disposal. Cost factors weigh in, with charges for hauling water ranging from 15¢ to more than $1 per gallon.

As permissible discharge limits are lowered, facilities may find it increasingly difficult to stay in compliance. Indeed, a facility that is permitted to discharge 50 ppm of organic waste may believe it is in a safe range if the content of its water is only 30 ppm of oil. To [illegible] severe [illegible] discharge [illegible] [illegible] times greater in size (Table 1).

The two main categories of emulsions are oil in water (OW) and water in oil (WO), with water including the most highly polar, hydrophilic (water-loving) liquids. Hydrophobic (water-hating) nonpolar liquids are considered [illegible]

[illegible]

[illegible] requires a basic understanding of emulsions, their chemical composition and the technologies required to remove them from water. Chemical engineers must ask what types of emulsions are involved and [illegible]

to get rid of them. Those who choose not to take this methodical approach, may be lucky and select the proper removal method. Otherwise, they will be stumped from the beginning.

TABLE 1. HOW PARTICLE SIZE COLORS EMULSIONS

Particle size (μm)	Emulsion appearance
Macro globules	Two phases may be distinguished
[illegible]	Milky-white emulsion
[illegible]	Blue-white emulsion
0.1–0.05	Gray, semitransparent
<0.05	Transparent microemulsion, with three or more phases

EMULSION BASICS

Whenever two immiscible liquids, such as oil and water, contact each other, one liquid tends to disperse, but not dissolve, in the other. This dispersion of liquid, typically in an aqueous medium, is an emulsion [illegible] smaller than 0.25 [illegible] [illegible] plants and [illegible]-type cleaners [1].

At equilibrium, the particle size of an emulsion's internal phase depends on the amount of emulsifier available to maintain that equilibrium. Hence, the concentration of an emulsifier must be balanced by its droplet size to keep par[illegible]

[illegible]

[illegible] 74% [illegible] and 12% [illegible] [1].

Emulsions consist of three phases. The internal, or discontinuous, phase consists of finely divided droplets. The external, or continuous, phase is the [illegible]

emulsifier, or stabilizer, that keeps the emulsion stable, binding the internal and external phases together, and preventing droplets from approaching each other and coalescing [2].

Usually emulsifiers are surfactants and soaps, present either by themselves or as part of the makeup of a detergent formulation. An emulsifier consists of a molecule with hydrophilic and hydrophobic ends. In the presence of immiscible liquids, the emulsifier migrates to the interface of the internal and external phases, forming a protective sheath around droplets of the dispersed phase, as shown in Figure 1. While the hydrophobic end of the molecule migrates, or partitions, into droplets, the hydrophilic end stays in the water [1, 2].

In effect, the emulsifier acts as a coupling agent, lowering the interfacial tension of the internal and external phases. When the interfacial tension is reduced to zero, an emulsion forms spontaneously. This means the surface area of the internal phase has reached its maximum. The dispersion of fine droplets, generally less than 1 μm dia., [illegible] appearance [illegible] can be achieved mechan[illegible]

[illegible] (COD), which includes any [illegible] bound that can be oxidized but may be more difficult to remove. And for facilities attempting to recycle water in a closed-loop process, FOGs simply cannot be ignored.

Some of the [illegible]

[illegible] required [illegible]

[illegible] determines the amount of stabilizer absorbed at the interface [2].

An important factor in emulsion stability is the diameter of the dispersed [illegible] of the dispersed phase and the [illegible]

George Alther, Biomin Inc.

[illegible]

HYDRITE EXHIBIT 1007

THE RIGHT BALANCE

A key consideration in the formulation of emulsions and, therefore, a factor in determining how they can be broken — is the hydrophile vs. lipophile balance

Flocculation, or aggregation, is a second process that takes place in emulsions with low internal-phase ratios, as typically found in wastewater. Particles slide together without coalescing to form clumps, or chains of clumps, of larger effective size. The settling rate then increases, even though the particles do not behave like spheres, as Stoke's Law demands [2].

Emulsifier solubility can be enhanced, if necessary, by adding a co-solvent or co-emulsifier, such as propylene glycol, that will act as a coupler to as-

settling velocity varies as the square of the particle diameter. Since oil's specific gravity is usually less than that of water

layer or phase because its specific gravity is lower than that of water.

If water is then blasted into the container, the physical impact of the water on the oil will cause some droplets to emulsify, or disperse, in the water. When the blast ceases, oil droplets will coalesce quickly.

A surfactant or emulsifier added to the container will disperse the oil into the water. The system can be imagined as a collection of small spheres dispersed in the continuous water phase.

APPLICATION	HLB NUMBER
Emulsifiers for water-in-oil (WO) systems	4–6
Wetting agents	7–9
Emulsifiers for oil-in-water (OW) systems	8–18
Detergents	13–15
Solubilizers	15–18

For an oil contaminant to be solubilized in water, the presence of a surfactant with a high HLB

Stable milky dispersion	10–13	

Water temperature can influence the efficiency of an emulsifier. Nonionic surfactants in aqueous solutions tend to be more soluble when the water is cold. As the temperature increases, turbidity increases to a maximum — cloud point. By determining the cloud point,

The creaming of an emulsion, or how fast an oil droplet will rise to the water's surface, is governed by Stoke's Law, which states

$$v = Gr^2(d_1 - d_2)/9\mu$$

Across the interface ... is an ... called the Zeta ... responsible for ... charge of the ...

viscosity of the emulsion. Large droplets rise ... than small ones, and drops move faster in a low-viscosity liquid. Therefore, if d_1 is less than d_2, the particle will rise, but if d_2 is larger than d_1, it will fall. The

be applied, depending on the emulsion type: a strongly hydrophilic surfactant, such as Polysorbate 80, or a strongly lipophilic surfactant, such as monoglyceryl or diglyceryl oleate, can break the emulsion [8].

Oil droplets in wastewater ... seem more likely to have a negative charge, as described by the Helmholtz theory of the electrical double layer, which states that if the negative charges are aligned or closely bound to

WASTEWATER EMULSIONS

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