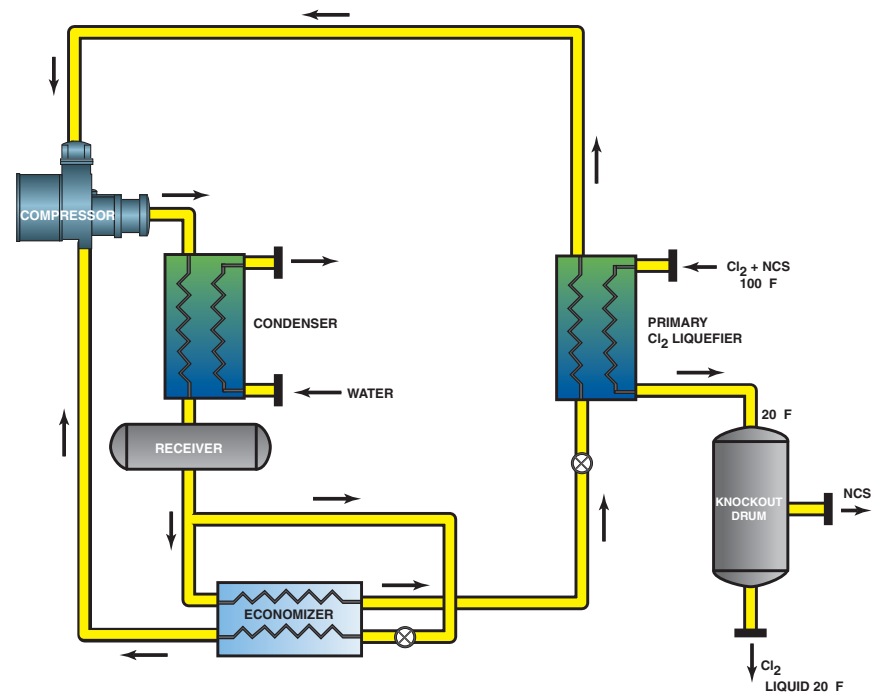


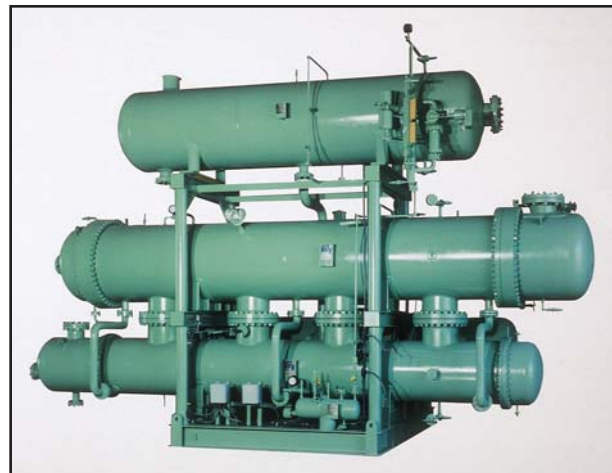
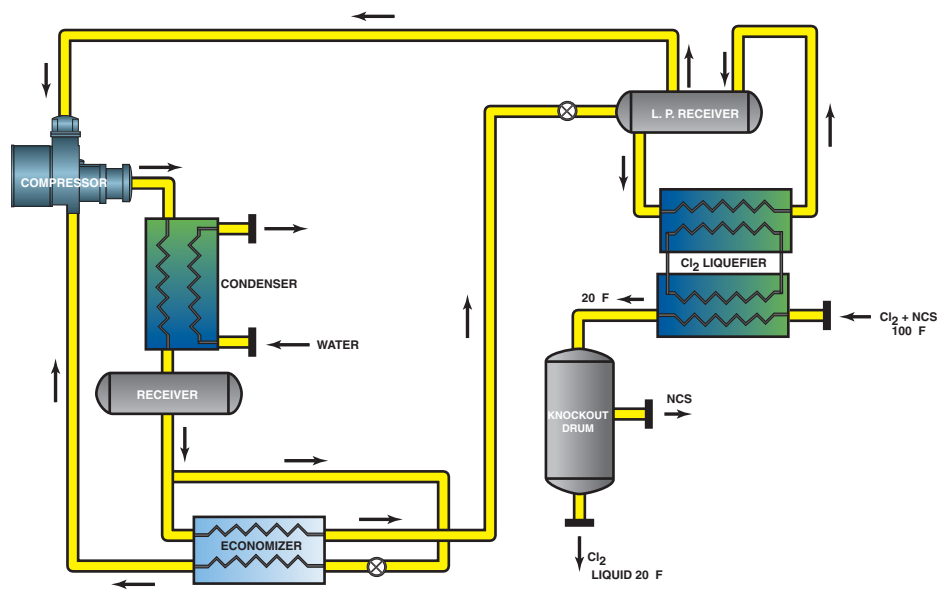
# Typical Process Diagrams

Figure 1: Primary Direct R-22 Cycle



## Chlorine Liquefaction Refrigeration Systems

Figure 2: Primary BOCOSI™ R-22 Cycle



# Safe And Innovative Refrigeration For The Chlorine Industry

FES is a global leader in industrial refrigeration and has brand name recognition, history, and roots to the chlorine industry through experienced personnel extending to 1960. Since 1985, FES has produced approximately 20 refrigeration systems for the chlorine industry including both centrifugal and screw type compressors.

FES heat transfer engineering personnel are familiar with the design of chlorine heat exchangers, gas separation issues, and handling of explosive mixtures. All process designs are done in-house. Heat transfer computer programs are used consistent with liquefaction know-how and practical experience.

FES has control technology disciplines within the application and engineering technical support groups. FES electrical control products are leaders in general screw refrigeration system control. This expertise is available in dealing with chlorine liquefaction system control, data acquisition, and report interface issues with client DCS environments. FES-developed control products include fiberglass enclosures for corrosive environments.

FES has a strong after-sale support team in service operations. These people are ready to assist customers on a global basis on issues of maintenance, repair, upgrade, retrofit, and refrigerant-change out. We can support new and used equipment, retrofit, upgrade or change-out options.

FES is a member of various organizations supportive to refrigeration system safety and worker training. FES maintains a customer school and has the ability to organize special schools which require focusing on unique issues to customers of the chlorine industry. FES is involved in the Chlorine Institute and proud to support their safety and technical awareness programs.

FES is your best source for chlorine process refrigeration systems—qualified by knowledge, experience, capability, and interest.



**Global FES Chlorine System Installations**

Vulcan Chemical  
PPG  
Occidental Chemical  
GE Plastics  
Olin Chemical  
Chlorine of Delaware  
Dupont  
BASF Wyandotte

Olin Chemical Polyvinyl Coatings  
Pequiven  
Cloro de Teuantepec  
Diamond Shamrock  
Niachlor  
B.F. Goodrich  
Magpro (Dead Sea Works)  
Electroclor

**Refrigerants**

FES has experience using HFC’s, CFC’s, and HCFC refrigerants. We offer both conventional direct and indirect refrigeration systems for liquefaction.

**Safety First**

Alternative refrigerant (HFC) and HCFC studies have indicated that the refrigerants and refrigerant oils pose a potential incident risk if exposed to chlorine due to a leak or rupture. This has required a new set of safety considerations for the designer and owner. CFC phase-out and the future phase-out of HCFC’s as required by the environmental laws have forced all responsible chlor-alkali producing companies to search for alternative ways to liquefy chlorine. New refrigerants and chlorine mixtures may present potential hazards.

FES is proud to be the authorized licensor of PPG’s BOCOSI™ patented indirect barrier heat transfer technology for use on chlorine liquefaction systems to meet concerns of users about possible side effects from use of new refrigerants within a Chlorine production environment. The heat exchanger in the BOCOSI™ cycle providing critical refrigeration effect can use HFC-134a, HCFC-22, or any other refrigerant or brine solution. The process heat exchangers (chlorine liquefiers) are connected in a “heat pipe” mode using a proprietary fluid that is totally inert to chlorine, thereby providing 100% separation between the chlorine process and the refrigeration process. Figure 2 illustrates the BOCOSI™ system.

**BOCOSI™**

BOCOSI™ systems are available to all users on a one time license fee basis administered by FES for PPG Industries, Inc. without administrative charge or profit by FES. Fee rates are driven by application type (new or retrofit) and capacity of chlorine process heat exchanger. FES developed the technology on physical design of BOCOSI™ process equipment to optimize performance and improve efficiencies.

The whole purpose of the BOCOSI™ system is to increase the safety of the chlorine liquefaction unit by separating the chlorine from the refrigerant and refrigerant oils.

Optimum designs by FES engineers have reduced first cost premiums and inefficiencies to a minimum over direct contact refrigerant approaches. Thus, the cost premium over direct refrigeration is minimized. Table 1 provides a rough comparison of first cost and operational cost at full capacity.

**Table 1: Conventional vs. BOCOSI™ Cost and Performance**

	Cl <sub>2</sub> Temp Out	Conventional Direct System		BOCOSI™ Indirect System	
		Relative Power	Relative Cost	Relative Power	Relative Cost
<b>Primary System</b>	15 °F	1.00	1.00	1.17	1.15
<b>Secondary System (Cascade to Primary)</b>	-60 °F	1.00	1.00	1.11	1.20

\* Current low temperature limit for BOCOSI™ is -60 °F