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FINAL REPORT

Municipal Water-Based Heat Pump Heating and/or Cooling Systems

Findings and Recommendations

Prepared by

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South Dakota Utilities Commission

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United States Department of Energy
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Background

Since the 1950s, geothermal heating and cooling systems based on heat pump technology have been one of the many energy options available to commercial, institutional, and residential structures. The Commonwealth Building in downtown Portland is recognized as the first major commercial building to incorporate the use of geothermal heat pumps for the provision of space heating, cooling, and domestic hot water. This system lead the way to numerous replications of the use of geothermal wells for heating and cooling. In the late 1970s, the Washington State Energy Office (now the Washington State University Energy Program) initiated the design of the nation's first heating and cooling system to use heat pump technology based on the use of a municipal water system. The Ephrata system, which was built with funding from HUD's Innovative Community Energy Systems Program, went on-line in 1980 and has served as a model for several similar systems in Washington State and across the U.S., receiving awards from both the U.S. Department of Energy and the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE). Geothermal-based as well as municipal water-based systems have proven to be extremely energy-efficient, environmentally responsible, and cost effective. The Ephrata system, using an 86°F water source, has reduced the energy consumption of the Grant County Courthouse and courthouse annex by approximately 80 percent, and has resulted in a cost savings, compared to the oil-fired boilers it replaced, of over 80 percent. Such systems can also serve as an additional source of revenue to municipal water systems as, for example, in Ephrata where the city charges the county for the thermal content of the water based on a percentage of the electrical input to the heat pump. Even water source heat pump systems based on 50°F water have resulted in energy savings of 50+ percent, reducing CO_2 and other air emissions by a similar amount. When the option is electrical resistance or even electrical air source heat pumps, water-source heat pump technology will reduce utility electrical peak demand by up to 50 percent, negating the need for significant increases in power generation capacity.

Such systems can also play a major role in distributed resource programs by reducing demand and thus serving to reinforce the utilities' existing transmission and distribution system. When coupled with thermal storage and centralized thermal distribution (district heating and/or cooling), even greater reductions in peak load demands are achievable.

The Problem

Although some geothermal heat pump systems have been in operation for 40+ years, and municipal water-based systems for over 15 years, many states have refused to allow such systems to be built and U.S. EPA, the American Water Works Association, and numerous state health departments have recently come out against the use of municipal water systems as heat sources or heat sinks due to:

1. The potential effect that increasing water temperature could have on the effectiveness of chlorine treatment for bacterial control.

2. The potential effect that increasing water temperature would have on rates of corrosion or scale formation and the possibility of metal species entering the water supply system from dissolution's of metals from piping connections, heat exchanger plates or tubes, or other equipment with which the domestic water comes into contact.

3. The possibility of contamination of domestic water supplies by heat pump working fluids, lubricants, or building circulation loops that often contain potentially toxic materials, i.e., cross connections.

4. Perceived or actual loss of control of municipal water system integrity and water quality by public as well as private purveyors of water from the time the water exits the municipal water supply until it is returned.

Present Study

The purpose of the present work was to determine if existing heat pump systems based on municipal water systems meet existing water quality standards, to analyze water that has passed through a heat pump or heat exchanger to determine if corrosion products can be detected, to determine residual chlorine levels in municipal waters on the inlet as well as the outlet side of such installations, to analyses for bacterial contaminants and/or regrowth due to the presence of a heat pump or heat exchanger, to develop and suggest criteria for system design and construction, to provide recommendations and specifications for material and fluid selection, and to develop model rules and regulations for the installation, operation, and monitoring of new and existing systems.

In addition, the Washington State University (WSU) has evaluated availability of computer models that would allow for water system mapping, water quality modeling and system operation.

Biological and metal analysis of all water samples were performed by the EPA Office of Drinking Water Laboratory in Cincinnati, Ohio, and duplicate samples were analyzed by the state health labs in Washington and South Dakota. For purposes of this report, ten heat pump installations were sampled: three in Washington State (Wapato City Hall, Walla Walla Community College, Corps of Engineers Walla Walla District Office) and nine in South Dakota (Rosebud PUD, Winner Middle School, Winner West School, Winner Medical Clinic, Pierre City Hall, Pierre Discovery Center, Bele Fourche Community Center, Deadwood Visitor Center, and Deadwood City Hall).

Sampling consisted of taking duplicate samples for biological analysis as well as metal analysis. Each of the systems was sampled both up stream (inlet side) and down stream (outlet side) of the heat pump/heat exchanger installation. Samples were immediately put into thermos containers and delivered to the laboratories within 24 hours of sampling. Samples from Washington State were analyzed by the Washington Department of Health Laboratory in Seattle, Washington, and by the EPA Office of Drinking Water Laboratory in Cincinnati, Ohio. Samples from South Dakota were analyzed by the Public Health Laboratory in Pierre, South Dakota, and by the EPA Cincinnati Laboratory. (Results of the analyses are detailed in Appendix I.) At the time of sampling, up stream and down stream water temperature, pH, and residual chlorine were measured for each system. Where instruments were available, pressure in the municipal water supply and in-building loop were also recorded.

Bacteriological Analysis

Samples 1A29797BC, 1B29797BC, 2A29797BC, and 2B29797BC for biological analysis were mishandled by the Cincinnati EPA Laboratory, so the samples were retaken.

Samples 2A29797BW and 2B29797BW taken at the Walla Walla Community College were found to contain unacceptable levels of coliform bacteria on both the up stream and down stream side of the heat pump installation. The water was found to be coming from the well in a contaminated state and was not chlorinated before passing through the heat pump installation. Both the college and municipality were notified of the problem. The problem was in no way related to the heat pump installation.

Sample CE3B24997BW from the Walla Walla Corps of Engineers' system and Samples 33 and 33A from the Belle Fourche Community Center system in South Dakota had the presence of coliform bacteria. However, duplicate samples were negative leading to a conclusion that the samples were contaminated during sampling. As a control, a third sample for the Corps of Engineers building was analyzed by the city and the results were negative.

All other samples analyzed for the presence of coliform bacteria were returned with a finding of no coliform bacteria present.

In addition, monthly samples from the systems in Winner, South Dakota, have been analyzed over the past three years. No sample over this period has been found to contain contaminants or bacterial regrowth.

In all cases analyzed, residual chlorine levels were approximately the same up stream and down stream of the heat pump installation, and within limits of sampling and meter sensitivity. Temperature increases ranged from ca 6°F to ca 14°F.

Pressure differentials between municipal supply and the in-building circulating loop ranged from ca 40 to ca 60 psi. This pressure differential will help ensure that should any leak occur in the heat exchanger, that fluids would flow from the municipal water supply into the user system.

Metals Analysis
A review of the results of the metal analysis did not show any consistent variations in metal concentrations from upstream to downstream side of the heat pump/exchanger. Where some variations occurred or were observable from sample to sample and from lab to lab, it does not appear from the information obtained that this is an area of major concern. Additional sampling further downstream of the heat pump/exchanger may, however, be warranted.

System Design Considerations
The single greatest concern as expressed by EPA. The American Water Works Association, state health officials, and local water system officials is the risk of cross connection.

The American Water Works Association (AWWA) Policy Statement on Cross Connections for the PNS-AWWA Cross Connection Control Manual states "...In addition, customer use of water from the community distribution system for cooling or other purposes within the customer's system and later returned to the community distribution is not acceptable and is opposed by AWWA." The AWWA continues "...Any potable water that is no longer in the water purveyor's distribution system is considered to be 'used water'... Whenever potable water is connected to a heat exchanger, or a heat exchanger is used to heat potable water, a hazardous cross connection may exist."

It is very clear from the above that the perceived risk associated with such installation is considerable and, according to policy statements by the AWWA, such applications should be discouraged if not outright barred or if allowed tightly regulated to minimize risk.

Over the course of this study, a number of heat pump installations were visited. They ranged from what appeared to those of adequate designs to those where the building operator/owner knew little about the system design, components used, or maintenance requirements. Although some of the systems reportedly incorporate double walled heat exchangers and materials were thought to be stainless steel, it was not always possible to confirm this information. Information concerning heat transfer fluids used within the building was often unavailable.

Considering that existing systems are likely to see continued use and that new systems are likely to be installed, we have attempted to evaluate different system designs, various system components (primarily heat exchangers and heat transfer fluids, that if required could go a long way in minimizing risk to municipal water supplies.

System Design
Figure 1 is a design concept prepared by Professor Wentz of the University of Nebraska, Department of Construction Management, College of Engineering and Technology. Professor Wentz has had considerable experience in the design of municipal water based heat pump systems, and willingly offered to provide a design incorporating a number of suggestions by the authors.

The design can accommodate a number of safeguards including temperature and pressure monitors that can activate system shut down valves should temperatures exceed a certain set point or pressure on either side of the heat exchanger should drop below preset levels. Of

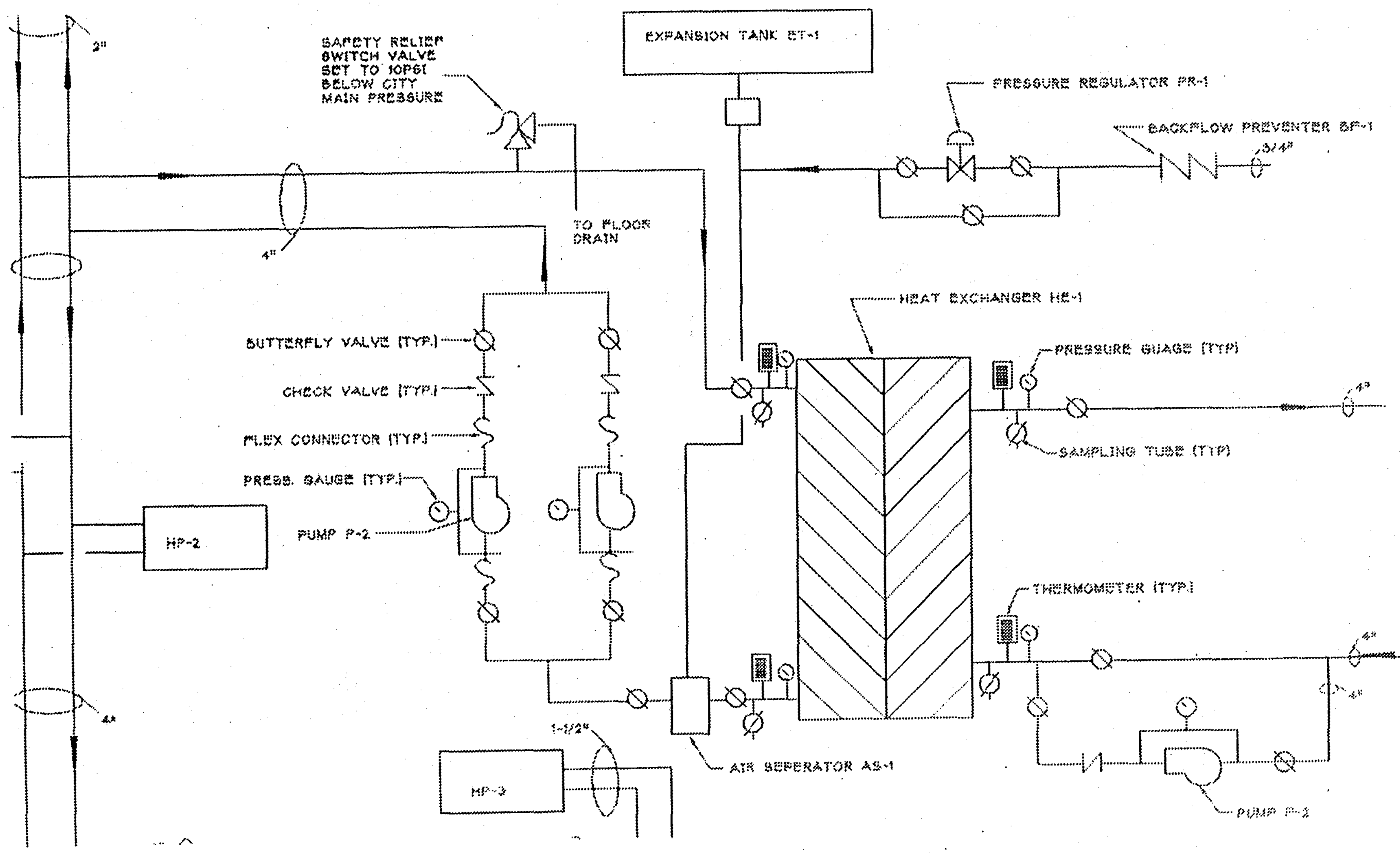


Figure 1 – Municipal Water Based Heat Pump System Design Concept

course, the system is designed to require a heat exchanger to separate the municipal water from the internal building loop. The system also provides for a pressure release valve should a leak occur in the heat exchanger. The pressure release valve can also be equipped with a monitor and/or alarm system. Incorporation of many of these design suggestions into future system installations is highly recommended, and would help ensure safe and reliable operation.

Heat Exchanger

The heat exchanger serves as the primary barrier between the municipal water supply system and the building's internal heat transfer circulating loop. A number of heat exchanger types and a number of heat exchanger configuration are possible to minimize the potential for cross connection.

Although most of those with whom we spoke felt that a single walled plate and frame exchanger either gasketed or brazed would provide adequate protection if constructed of stainless steel; more secure exchangers are also available (see Exhibit A).

The double walled heat exchanger, available in both tube and shell and plate and frame configurations, provides a secondary barrier and should a leak occur in either plate, the system will leak to the outside where a leak detector could provide for automated shut down and/or an alarm. Another double walled exchanger is the shell and coil heat exchanger (see Exhibit B.). This type of exchanger is widely used in Scandinavia in district energy applications. In this type of heat exchanger, coils of either copper tubing or stainless steel are wound tightly around each other to provide excellent heat transfer while at the same time no possibility of fluid interaction. Plate and frame heat exchanger are widely used in the food processing industry in such applications as, for example, pasteurizing milk, beer and fruit juices, and in chilling wines, beer, and soft drinks. Finally, both plate and frame and shell and coil heat exchangers can be installed in series. Although this may be most appropriate when using a single walled heat exchanger, it is a perfectly sound arrangement even with double walled exchangers, although cost would be a major factor with at least some of the exchanger and there would also be increased pumping requirements, especially through the plate and frame units. It appears that flow through the shell and coil exchanger would be less restricted and thus would result in a smaller pumping penalty.

Heat Transfer Fluids

Another major concern of the AWWA, state health officials, and many water purveyors was the composition and especially the potential toxicity of the heat transfer fluid on the building side of the installation. Many of the commonly used heat transfer fluids are potentially toxic and no matter how small the risk of cross contamination, should probably be avoided.

There are, however, some heat transfer fluids that would seem to be acceptable for such applications. These fluids are based on propylene glycol. The most commonly referred to of these is the product DOWFROST (see Exhibit C) made by Dow Chemical Company. DOWFROST is approved for use in food industry applications, and is used in such applications as making ice beer; in breweries, wineries, dairies, and fruit (juice) processing to cool liquids; in vending machines, bars and restaurants; for immersion freezing of wrapped foods; and for ice making. The product contains corrosion inhibitors, and is toxic to bacteria in concentrations of 15 to 20 percent and above. For most applications, a solution of 30-50 percent DOWFROST is recommended, and is well above that level where bacteria can survive. The company provides free testing of the product on an annual basis, and will test at more frequent intervals although at a cost to the user. If the fluid is maintained according to manufacturer specifications, no contamination products should form. This and possibly similar products by other manufacturers would seem to be a logical requirement in these applications.

Installers

Another area of concern has been whether or not special certification should be required for those installing these installations. The general consensus is that plumbing codes and the use of certified plumbers should be perfectly adequate, although the authors question whether or not general contract plumbers have adequate training in pressure testing or in handling heat transfer fluids of the type we are suggesting be required. This is definitely an area that requires more in-depth evaluation.

Water System Regulations and Contract Provisions

One of the most often raised concerns by water purveyors and the AWWA is the actual or perceived loss of control over that portion of the municipal water system that interfaces with the customer's system. Even in those instances where the system has been installed in full knowledge of and complete compliance with the desires of the water purveyor, there is still the feeling that once the system is in operation, the water purveyor no longer has control.

This situation can be most easily remedied by the establishment of rules and regulations related to the installation and operation of these systems and through contract provisions that bind the two parties together (Supplier and Customer) and clearly define responsibilities, access, equipment and materials specifications, testing requirements, and grievance procedures. A number of draft provisions that address these issues are presented in Appendix II of this report.

Computer Modeling

Another task was to evaluate the availability of computer models that would allow for system analysis and water quality modeling. It appears from the literature, personal communications, and in-depth familiarization with one such model (LICWATER) that such models are readily available and that their applications could provide relevant information. However, it has also become clear that applications of such models is very data intensive, costly, and probably not warranted. Most water purveyors with whom we discussed the question felt that they had an extremely good working knowledge of their own system related to water flows, and felt that applying such detailed models would not be beneficial unless wide-spread use of municipal water for heat pump systems were proposed.

Summary and Recommendations

From the limited number of installations that were sampled in the two states, it appears from the data that such systems have limited detectable impact on water quality, biological growth, metal concentration, and residual chlorine. However, this data reflects analysis of water samples taken in close proximity to the heat pump/heat exchanger installation and not at some location considerably downstream of such installation where some residual impact may occur according to some people with whom we discussed the problem.

It was also clear that there were few standards for such installations either in terms of design and/or materials used.

It is our recommendation that if installation of these systems is to be continued, and that if existing systems are to remain in operation, that standards in design, construction, and material specifications be adopted and that water purveyors adopt not only standards for installation, operation, maintenance, and monitoring, but also regulations related to system access and testing (see Appendix II).

If such measures are taken, we believe that these systems can be operated in a safe manner, and while risk can never be eliminated, these measures would go a long way to minimize such risk.

The question then becomes one of economics and whether or not such systems can be designed to meet required levels of risk minimization while at the same time remaining a cost-effective and energy-efficient alternative.

Appendix I

Results of Water Analysis Performed by Washington Department of Health Laboratory, South Dakota Public Health Laboratory, Environmental Protection Agency Office of Drinking Water Laboratory.

South Dakota - Bacteria

Sample		City	Location		Temp F	pH
1D	Return	Rosebud REC	Gregory	Bacteria	65	7
1A	Return	Rosebud REC	Gregory	Bacteria	65	7
2D	Supply	Rosebud REC	Gregory	Bacteria	59	7
2A	Supply	Rosebud REC	Gregory	Bacteria	59	7
3RD	Return	Rosebud REC	Gregory	Metal	65	7
3A	Return	Rosebud REC	Gregory	Metal	65	7
4S	Supply	Rosebud REC	Gregory	Metal	59	7
4SAD	Supply	Rosebud REC	Gregory	Metal	59	7
5R	Return	Winner	Middle School	Bacteria	68	7
5ARD	Return	Winner	Middle School	Bacteria	68	7
6S	Supply	Winner	Middle School	Bacteria	60	7
6ASD	Supply	Winner	Middle School	Bacteria	60	7
7R	Return	Winner	Middle School	Metal	74	7
7ARD	Return	Winner	Middle School	Metal	74	7
8S	Supply	Winner	Middle School	Metal	68	7
8AS	Supply	Winner	Middle School	Metal	68	7

Sample		City	Location		Temp F	pH
9RD	Return	Winner	West School	Bacteria	74	7
9AR	Return	Winner	West School	Bacteria	74	7
10S	Supply	Winner	West School	Bacteria	64	7
10ASD	Supply	Winner	West School	Bacteria	64	7
11RD	Return	Winner	West School	Metal	78	7
11AR	Return	Winner	West School	Metal	78	7
12SD	Supply	Winner	West School	Metal	78	7
12AS	Supply	Winner	West School	Metal	78	7
13R	Return	Winner	Clinic	Bacteria	60	7
13ARD	Return	Winner	Clinic	Bacteria	60	7
14S	Supply	Winner	Clinic	Bacteria	72	7
14ASD	Supply	Winner	Clinic	Bacteria	72	7
15R	Return	Winner	Clinic	Metal	60	7
15AR	Return	Winner	Clinic	Metal	60	7
16S	Supply	Winner	Clinic	Metal	72	
16ASD	Supply	Winner	Clinic	Metal	72	
17R	Return	Pierre	City Hall	Bacteria	55	7
17AR	Return	Pierre	City Hall	Bacteria	55	7
18SD	Supply	Pierre	City Hall	Bacteria	55	7
18AS	Supply	Pierre	City Hall	Bacteria	55	7

Sample		City	Location		Temp F	pH
19R	Return	Pierre	City Hall	Metal	55	7
19ARD	Return	Pierre	City Hall	Metal	55	7
20SD	Supply	Pierre	City Hall	Metal	56	7
20AS	Supply	Pierre	City Hall	Metal	56	7
21RD	Return	Pierre	Discovery Center	Bacteria	50	7
21AR	Return	Pierre	Discovery Center	Bacteria	50	7
22SD	Supply	Pierre	Discovery Center	Bacteria	52	7
22AS	Supply	Pierre	Discovery Center	Bacteria	52	7
23R	Return	Pierre	Discovery Center	Metal	52	7
23ARD	Return	Pierre	Discovery Center	Metal	52	7
24S	Supply	Pierre	Discovery Center	Metal	50	7
24AS	Supply	Pierre	Discovery Center	Metal	50	7
25S	Supply	Belle Fourche	Community Center	Bacteria	68	7
25SA	Supply	Belle Fourche	Community Center	Bacteria	68	7
26D	Return	Belle Fourche	Community Center	Bacteria	70	7
26A	Return	Belle Fourche	Community Center	Bacteria	70	7

Sample		City	Location		Temp F	pH
27	Bacteria	Belle Fourche	Community Center	Bacteria	70	7
27AD	Bacteria	Belle Fourche	Community Center	Bacteria	70	7
28P	Supply	Deadwood	City Hall	Bacteria	52	7
28A	Supply	Deadwood	City Hall	Bacteria	52	7
29	Return	Deadwood	City Hall	Bacteria	62	7
29A	Return	Deadwood	City Hall	Bacteria	62	7
30	Supply	Deadwood	City Hall	Bacteria	62	7
30A	Supply	Deadwood	City Hall	Bacteria	62	7
31D	Supply	Deadwood	Visitor Center	Metal	58	8
31A	Supply	Deadwood	Visitor Center	Metal	58	8
32D	Return	Deadwood	Visitor Center	Metal	70	8
32A	Return	Deadwood	Visitor Center	Metal	70	8
33D	Return	Deadwood	Visitor Center	Bacteria	70	8
33A	Return	Deadwood	Visitor Center	Bacteria	70	8
50	Supply	Deadwood	City Hall	Bacteria	60	7
50	Supply	Deadwood	City Hall	Bacteria	60	7
51	Return	Deadwood	City Hall	Bacteria	64	7
51	Return	Deadwood	City Hall	Bacteria	60	7
52	Supply	Deadwood	City Hall	Metal	60	7
52A	Supply	Deadwood	City Hall	Metal	60	7
53	Return	Deadwood	City Hall	Metal	60	7
53A	Return	Deadwood	City Hall	Metal	60	7

Sample		City	Location		Temp F	pH
54	Supply	Deadwood	Visitor Center	Bacteria	50	7
54A	Supply	Deadwood	Visitor Center	Bacteria	50	7
55	Return	Deadwood	Visitor Center	Bacteria	50	7
55	Return	Deadwood	Visitor Center	Bacteria	50	7
56	Supply	Deadwood	Visitor Center	Metal	60	7
56	Supply	Deadwood	Visitor Center	Metal	60	7
57	Return	Deadwood	Visitor Center	Metal	50	7
57	Return	Deadwood	Visitor Center	Metal	50	7
58	Supply	Belle Fourche	Community Center	Bacteria	64	7
58	Supply	Belle Fourche	Community Center	Bacteria	64	7
59	Return	Belle Fourche	Community Center	Bacteria	62	7
59	Return	Belle Fourche	Community Center	Bacteria	62	7
60	Supply	Belle Fourche	Community Center	Metal	62	7
60A	Supply	Belle Fourche	Community Center	Metal	62	7

South Dakota - Bacteria

Sample	Total Coliform Bacteria	Res. Chlorine
1A	<1	.020
2A	<1	.020
3RA	<1	.020
4SA	<1	.020
5R	<1	.020
6S	<1	.020
7A	<1	.020
8AS	<1	.020
9AR	<1	.200
10S	<1	.200
11AR	<1	.200
12AS	<1	.200
13A	<1	.100
14S	<1	.090
15AR	<1	.100
16AS	<1	.090
17R	<1	.025
18AS	<1	.200
19AR	<1	.090
20AS	<1	.200
21AR	<1	.190
22AS	<1	.190
23AR	<1	.190
24AS	<1	.190
25S	<1	1.300
26A	<1	1.300
27	<1	1.300
28	<1	1.000
29	<1	1.000
30A	<1	1.000
31A	<1	1.200
32	<1	1.200
33A	<1	1.200
50	<1	1.900
51A	<1	1.900
52A	<1	1.900
53A	<1	1.900
54A	<1	1.800
55	<1	1.800
56	<1	1.800
57	<1	1.800
58	<1	2.000
59	<1	2.000
60A	<1	2.000

South Dakota – Metals

Lab ID	Sample ID	Cd (ug/l)	Cr (ug/l)	Cu (mg/l)	Fe (ug/l)	Ni (ug/l)	Pb Icap (ug/l)	pH	Temp	Zn (ug/')	Lab
33671	3RA	<5	<6	0.014	37	<15	<30			47	EPA
E97IN004901	3R-R			<0.020		0.92	<5.9	7	65	188	SD Pub. Health
E97IN004902	4SA-S			0.004		1.50	1.31	7	65	5.27	SD Pub. Health
33672	5R-R	<5	<6	0.004	<3	<15	<30	7	68	<1	EPA
E97IN004903	5AR-R			<0.020		1.43	3.1	7	68	<50	SD Pub. Health
33668	8AS-S	<5	<6	0.004	31	<15	<30			<1	EPA
E97IN004904	8S-S			<0.020		1.38	5.1	7	74	<50	SD Pub. Health
33667	11AR-R	<5	<6	0.004	49	<15	<30			3	EPA
E97IN004900	11R-R			<0.020		1.17	1.1	7	78	<50	SD Pub. Health
33669	12AS-S	<5	<6	<0.003	208	<15	<30			<1	EPA
E97IN004899	12S-S			<0.020		1.26	6.6	7	78	<50	SD Pub. Health
E97IN004898	15AR-R			<0.02		1.11	1.80	7	60	<50	SD Pub. Health
E97IN	16AS-R			<0.02		1.17	<0.80	7	72	<50	SD Pub. Health
E97IN004908	19AR-R			0.07		18.90	2.60	7	55	<50	SD Pub. Health
33670	20AS-S	<5	<6	0.292	392	<15	<30			<1	EPA
E97IN004906	20S-S			0.310		5.26	<0.80	7	--	<50	SD Pub. Health
E97IN004905	23AR-R			0.070		6.23	4.7	7	52	<50	SD Pub. Health
E97IN004907	24AS-S			0.020		5.14	1.3	7	50	<50	SD Pub. Health
34033	25S-S	<5	<6	0.017	<3	<15	<30	7	70	4	EPA
34034	26-R	<5	<6	0.120	<3	<15	<30	--	--	<1	EPA
E97IN005592	26A-R	<5	1.73	0.020		1.68	0.90	7	70	<50	SD Pub. Health
34035	28-S	<5	<6	0.032	54	<15	<30			220	EPA
E97IN005593	28A-S	<0.5	2.54	<0.020		1.45	2.7	7	52	<50	SD Pub. Health
Det. Limit		**<5**	**<6**	**<0.003**	**<3**	**<15**	**<30**			**<1**	

Lab ID	Sample ID	Cd (ug/l)	Cr (ug/l)	Cu (mg/l)	Fe (ug/l)	Ni (ug/l)	Pb Icap (ug/l)	pH	Temp	Zn (ug/')	Lab
34036	29A-R	<5	<6	0.004	<3	<15	<30			<1	EPA
E97IN005594	29-R	<0.5	<2.62	<0.020	1.64	2	3.9	--	62	86	SD Pub. Health
34037	31A-S	<5	<6	0.010	<3	<15	<30			<1	EPA
E97IN005595	31-S	<5	2.55	<0.02		1.58	10.2	8	58	<50	SD Pub. Health
34038	32	<5	<6	0.028	<3	<15	<30			2	EPA
E-97IN005596	32A-R	<5	2.98	<0.020		1.54	2.5	8	70	<50	SD Pub. Health
34404	50	<5	<6	0.033	<3	<15	<30			2	EPA
E98IN008045	50A	<5	5.46	0.040		1.70	<.80	7	60	<2.70	SD Pub. Health
34405	51A	<5	<6	0.329	<3	<15	<30			<1	EPA
E97IN008046	51	<5	<6	0.330		1.74	0.9	7	64	<2.70	SD Pub. Health
34406	54A	<5	<6	0.005	<3	<15	<30			134	EPA
E97IN008036	54	<5	<6.10	<0.020		1.67	<0.8	7	52	5.99	SD Pub. Health
34407	55	<5	<6	0.015	<3	<15	<30			2	EPA
E97IN008039	55A	<50	5.09	<0.020		1.75	<0.80	7	50	2.50	SD Pub. Health
34408	58A	<5	<6	0.013	<3	<15	<30			2	EPA
E97IN008040	58	<50	5.25	<0.020		1.81	1.1	7	64	3.97	SD Pub. Health
34409	59	<5	<6	0.014	<3	<15	<30			1	EPA
E97IN008041	59A		4.80	<0.02	1.83		<80	7	63	<2.70	SD Pub. Health
Det. Limit		<5	<6	<0.003	<3	<15	<30			<1	

Washington State

County	Location	System Name	Source Type	Sample Type	Res. Chlorine	pH	Temp	Coliform	Lab
Walla Walla	Corps of Engineers	1A29797BW Inlet	Purchased or Intertie	Drinking Water	0.40	7	64	Satisfactory	WA Pub. Health Lab
Walla Walla	Corps of Engineers	1B29797BC Outlet	Purchased or Intertie	Drinking Water	0.38	7	66	Satisfactory	EPA
Walla Walla	Community College	2A29797BW Inlet	Well or Well Field	Raw Source Water	NA	7	60	Coliform CFU/L2/100 mi Fecal L2/100 mi	WA Pub. Health Lab
Walla Walla	Community College	2B29797BW Outlet	Well or Well Field	Raw Source Water	NA	7	64	Coliform CFU/L2/100 mi Fecal L2/100 mi	WA Pub. Health Lab
Walla Walla	Corps of Engineers	CE3A24997BW Inlet	Purchased or Intertie	Drinking Water	0.69	6	54	Satisfactory	WA Pub. Health Lab
Walla Walla	Corps of Engineers	CE3B24997BWC Outlet	Purchased or Intertie	Drinking Water	0.82	6	64	Present/Unsatisfactory. E. Coli absent	EPA
Wapato	City Hall	W4A24997BC Inlet	Purchased or Intertie	Drinking Water	X	6	68	Satisfactory	EPA
Wapato	City Hall	W4B24997BW Outlet	Purchased or Intertie	Drinking Water	X	6	80	Satisfactory	WA Pub. Health Lab
Walla Walla	Corps of Engineers	925002A Inlet	Purchased or Intertie	Drinking Water	0.73	NA	NA	Satisfactory/Absent	Walla Walla Water Qual. Lab
Walla Walla	Corps of Engineers	925002A Outlet	Purchased or Intertie	Drinking Water	0.86	NA	NA	Satisfactory/Absent	Walla Walla Water Qual. Lab

Washington - Bacteria

Sample	Total Coliform Bacteria	Res. Chlorine
W4A24997MC	<1	
W4B24997MC	<1	
CE3A24997MW	<1	
CE3B24997MW	<1	
CE3A24997MC	<1	
CE3B24997MC	<1	
1A29797MW	*	*
1B29797MW	*	*
2A299797MW	*	*
2B299797MW	*	*

*Samples not analyzed by EPA

Washington – Metals

Lab ID	Sample ID	Cd (ug/l)	Cr (ug/l)	Cu (mg/l)	Fe (ug/l)	Ni (ug/l)	Pb Icap (us/l)	pH	Temp	Zn (ug/l)	Lab
COE-Walla Walla	1A29797MW Inlet			<0.2		<20	<2			<20	WA Pub. Health Lab
33856	1AMC Inlet	<5	<6	0.102	15	<15	<30			3	EPA
COE-Fire Hydrant-Walla Walla	1B29797MW Outlet			<0.2		<20	2			<20	WA Pub. Health Lab
33858	1BMC Outlet	<5	<6	0.004	11	<15	<30			8	EPA
Walla Walla Community College Well	2A29797MW Inlet		<10	<0.2	<10	<20	20				WA Pub. Health Lab
33857	2AMC Inlet	<5	<6	0.052	<3	<15	31			21	EPA
Walla Walla Twin Reservoir	2B29797MW Outlet			<0.2		<20	<2			<20	WA Pub. Health Lab
33859	2BMC Outlet	<5	<6	<0.003	<3	<15	<30			<1	EPA
COE Walla Walla	CE3A24997MW Inlet			<0.200	58	<20	4			<20	WA Pub. Health Lab
34215	CE3A24997MC Inlet	<5	<6	0.035	1,172	<15	<30			13	EPA
34216	CE3B24997MC Outlet	<5	<6	0.035	427	<15	<30			13	EPA
COE Walla Walla	CE3B24997MW Outlet			<0.2	23	<20	10			<20	WA Pub. Health Lab
34123	W4A24997MC Inlet	<5	<6	<0.003	<3	<15	<30			2	EPA
34214	W4B24997MC Outlet	<5	<6	0.023	45	<15	<30			23	EPA

Appendix II

Suggested Contractual Provisions and Regulations That Define Rights and Obligations of Water Suppliers and Customers.

Example I

SUGGESTED CONTRACTUAL PROVISIONS THAT DEFINE RIGHTS AND OBLIGATIONS OF WATER SUPPLIERS AND CUSTOMERS

Contracts or service agreements include terms that define where the supplier's system ends and the customer's begins, and allocate responsibilities for furnishing, installing, maintaining and repairing various components of the system. A common arrangement is for the supplier to be responsible for parts of the system up to the point of connection with the customer's building and for any metering devices, while the customer is responsible for equipment within its own building. Sample provisions follow:

* * *

All of the Customer's system between the service valves, except for metering devices, shall be owned and controlled by the Customer.
...The supplier...(shall not) have any responsibility...for the use or handling of the water while between the two service valve points...**The supplier shall furnish and maintain the necessary metering devices for on or in the Customer's premises. In no event shall the metering devices be considered the property of the Customer.**

* * *

All equipment placed in the building by the supplier for the purpose of furnishing...including without limitation all meters, **shall be and remain the property of the supplier** and Customer shall exercise reasonable care to protect such equipment from loss or damage.

Customer shall furnish, install and maintain...on the service side of the meter, such pumps and regulating devices as are necessary to maintain pressure and flow conditions required by Customer's equipment... **Customer shall also furnish, install and maintain all facilities required for its utilization of Services...**

Customer shall provide (without cost to the supplier) suitable space for the installation, inspection, protection and maintenance of the supplier's meters and other necessary equipment within Customer's premises...Customer shall furnish, install wiring, piping and equipment necessary to provide (electric) service.

* * *

Without the consent of the supplier, **Customer shall not cause or voluntarily permit any modification or alteration to any part of the metering equipment or the water supply system...**

* * *

Water suppliers need access to their customers' premises and equipment located there for several reasons. When customer rates are based on metered usage, the meters are normally located on the customer's premises, and the supplier is responsible to read them at regular (usually monthly) intervals. In addition, some of the supplier's own equipment may be located on its customers' premises, so access is needed to maintain and repair it. Finally, since the customer's own equipment is an integral part of the supplier's system, the supplier needs to be able to inspect and possibly to service, repair, remove and/or replace the equipment. Contracts or service agreements usually recognize these needs and include provisions defining the parties' rights and responsibilities concerning access and inspections, as follows:

* * *

Permission is given the supplier to enter the Customer's premises at all reasonable times, for the purpose of inspecting any part of the Customer's system, and for such purpose the Customer authorizes and requests his landlord, if any, to permit the supplier to enter said premises. Where the repair of defective parts, equipment, or appliances on his system is necessary in order that all condensation may be registered, the Customer shall make such repairs at once, or allow the supplier to do so at the Customer's expense. ...

Permission is given the supplier to enter the Customer's premises at all reasonable times, for the purposes of reading its meters, and operating, inspecting and keeping in repair or removing any or all of its apparatus used in connection with the supply of water, and for said purposes the Customer authorizes and requests his landlord, if any, to permit the Company to enter said premises.

* * *

The Customer grants the supplier the right to enter the Customer's premises at any reasonable time **for the purpose of installing, inspecting, testing, repairing, altering, or removing any of the supplier's property**. ...

* * *

Duly authorized agents, officers, and employees of the supplier shall have the right to enter into the building or onto the surrounding premises of Customer at reasonable times when necessary for inspection, repair, replacement, construction, installation, removal, alteration or calibration of the metering equipment and the district heating system, subject to reasonable supervision and control by the Customer. ...

* * *

Suppliers are usually entitled to terminate service for conditions such as customer non-payment, customer maintenance failures or safety violations, damage to or destruction of the supplier's facilities or the customer's premises, governmental actions or other events beyond the supplier's control, or customer fraud.

* * *

<u>TERMINATION BY (SUPPLIER)</u>
Supplier may terminate this Agreement, discontinue the delivery of water to Customer, enter the building and remove all of Supplier's equipment, including without limitation all meters...upon the happening of any one of the following events:

(a) **Failure of Customer** to pay in full, within 30 days of billing...

(b) **Failure of Customer to construct, maintain and operate its equipment as required in the conditions of service...**

(c) **The withdrawal of any (essential) government authority...or** the enforcement by any governmental authority of any rule or regulation which prevents Supplier from furnishing water as required (by this Agreement)...

Supplier agrees to give Customer 30 days' written notice prior to the exercise of its right to terminate this Agreement...and...with respect to curable defaults referred to in (sub-paragraph) (b) only, **(time to cure)**. Customer agrees to indemnify Supplier against all losses and charges which Supplier may incur by reason of termination (on certain grounds)...

* * *

The supplier may refuse or discontinue service and remove its property without being liable to the Customer, or to tenants or occupants of the premises...for any of the following reasons:

(a) **Customer's failure to comply with any of the provisions of the contract**, or any applicable regulations, or any of the supplier's applicable rules or practices currently in effect.

(b) Customer's **failure to maintain his equipment in safe condition...**

(c) Withdrawal or termination of the proper permits, certificates or rights-of-way.

(d) Evidence of **fraud**.

(e) **Unauthorized adjustment or tampering with supplier's equipment.**

The supplier may discontinue service without notice for reasons (d), and (e) above.

Example II

REGULATIONS FOR THE DELIVERY OF WATER FOR HEATING AND/OR COOLING PURPOSES

Supplier's System

1. The Supplier is responsible for, pays for, and owns the system up to the point of connection as determined by the Supplier.

The system's design and location is determined by the Supplier after consultation with the customer. The Supplier determines requirements for pressure and temperature as well as other technical parameters.

2. Metering equipment is provided by the Supplier. The location of the metering equipment is determined by the Supplier after consultation with the customer and must provide for free access by the Supplier.

Installation

3. Installation includes piping for the system as well as heat exchangers or other equipment which is in direct contact with the water system.

4. Customer may not, without written permission of the Supplier, change or modify the installation. The Supplier shall determine pressure, temperature, and all other parameters as well as the technical design.

Customer Station

5. The customer shall, without cost to the Supplier, be responsible for the customer station which shall contain the heat exchanger and all associated equipment. The customer station shall be kept accessible to the Supplier. A key box shall be provided and maintained by the customer within the customer's premises unless other acceptable arrangements have been made.

6. The customer station may not be used for any purpose which will interfere with system operation or which will impede access.

The customer shall be responsible for cleaning, lighting, and maintenance of the customer station.

Secondary System

7. The secondary system is made up of the customer's heating, cooling, and domestic hot water systems.

8. Installation, modification, and repairs to the secondary system shall be made according to standard practice and requirements of the Supplier.

9. The secondary system must be well maintained. The customer must, upon request, provide the Supplier with information concerning the operating condition of the secondary system and the heating and/or cooling efficiency of the secondary system.

The Supplier may require such modifications to the secondary system which are necessary to make it operate most efficiently.

Testing and Approval

10. The customer's installation may not be put into operation before it is pressure tested and approved by the Supplier. Pressure testing shall be paid for by the customer.

11. The Supplier has the right to inspect the customer's installation and its use.

12. The customer must provide the Supplier access to the secondary system for testing and inspection.

13. The Supplier's testing and approval of the installation does not imply that the Supplier is in anyway responsible for the condition of the customer's installation, customer station, or secondary system. Nor does it free the customer's or the installer of the system from responsibility and obligation for the system.

Operation

14. The customer shall insure that water from the Supplier's system is not tapped without his written permission and shall pay damages for water which is tapped or leaks from the customer's system due to problems with the installation.

The customer shall immediately report any operational problems, leakage, or any other irregularities in operation to the Supplier.

The customer shall operate valves belonging to the Supplier only with the Supplier's written permission and then only in accordance with his directions.

Disruption of Supply

15. The Supplier shall not be liable for disruptions in supply beyond his control. The Supplier is justified in disrupting service if there is a danger of personal injury or property damage or in order to make repairs which are necessary to ensure continued service.

If the Supplier anticipates the necessity for a disruption in service, he shall provide reasonable notice to the customer.

16. If service must be disrupted under paragraph 15, or will be available in limited quantities, the Supplier has the right to apportion the available quantities among the customers. The Supplier has the right to install equipment in the customer station to permit any such apportionment.

Use of Property for Supplier's Equipment

17. For purposes of installing, maintaining, and repairing the Supplier's equipment, the customer shall grant the Supplier unlimited access to his property.

a. The customer may not construct any structures, change the surface of the property, or store materials closer to the water pipes than agreed upon with the Supplier.

b. If the customer transfers ownership of the property or building housing the Supplier's equipment, he shall make it a condition of the transfer to guarantee the rights reserved to the Supplier in point a above.

c. The customer shall, if requested to do so, sign a service agreement covering the Supplier's equipment.

Changes and Additions

18. The Supplier retains the right to change or make additions to these uniform regulations and fee schedules. The customer shall be notified in writing a minimum of three months before any changes or additions in these uniform regulations take effect.

19. The Supplier may reach agreement with the customer on any and all questions that are not regulated in these uniform regulations or fee schedules.

Example III

CONDITIONS FOR THE OPERATION OF INSTALLATIONS

The installations of the customer's system must be made in accordance with the Supplier's "Technical Specifications."

Where the installations of a property are not in accordance with the specifications or where maintenance is insufficient or faulty and where in the Supplier's opinion these defects can inflict damage or loss upon the Supplier, the owner shall at Supplier's request see to it that the defects are repaired satisfactorily.

Failing that, the Supplier has the right to have the defects repaired at the customer's expense or to interrupt service.

It is the responsibility of the customer that no water is removed from the Supplier's distribution system.

If repairs or similar work require that water is removed from the pipes, notification must be made to the Supplier. Removal of water is not permissible without permission of the Supplier.

Example IV

TECHNICAL SPECIFICATIONS

1. Branch Pipes, Main Shut Off Valves, Meters, etc.

1.1 Branch pipes including main shut off valves are designed and installed by the Supplier.

1.2 The Supplier installs the branch pipes connecting the transmission pipelines with the main shut off valves, which are usually installed in the property's mechanical room on the inner side of the outer wall facing the street.

Branch pipes may, in special cases, be installed in service space or similar places for alternative installation of the main shut off valves.

Under special circumstances, the main shut off valves may be installed outside the building.

1.3 The branch pipe leading to the main shut off valves is continued on the other side of the main shut off valves by a fitting pipe, provided by the Supplier and installed by the customer's plumber for later replacement by a meter.

1.4 The Supplier provides and installs the complete meter. The meter is installed in the return pipeline in close proximity to the meter, the customer establishes a non-switch off power supply.

1.5 The meter is installed after the plumber has established connection between the main shut off valves and the system and after pressure testing has been performed.

2. Water Supply

2.1 Prior to installing the equipment, the connection arrangement must be approved by the Supplier.

2.3 If the water is to be heated the temperature of the return flow must not exceed ______°C.

In order to ensure that the required temperature is in compliance with, the Supplier may require that a thermovalve be installed in the system, which is set to close when the temperature exceeds _________°C.

2.4 The system must be installed according to the Supplier's specifications. The maximum pressure in the customer system forward pipeline is _________ bar.

2.5 The differential pressure at the Subscriber's system station amounts to a minimum of _________________ bars; however, the differential pressure may vary from ___________ to _________ bar depending on time and location. This is a specification which must be complied with when designing the customer side of the system.

2.6 On the primary side of the heat exchanger, the installation of equipment and the materials and components used must be in accordance with _________, and the equipment must be tested at a cold-water pressure of _________ bar. Furthermore, the equipment must comply with the local authorities' specifications for water systems.

2.7 Connection must be performed by a plumber in accordance with the Supplier's instructions and at the customer's expense.

2.8 Removal of water from the Supplier's pipe system is not permissible without the Supplier's permission.

4. Pressure Testing

4.1 Prior to connection and in case of repair and other alterations, a plumber shall, under the supervision of the Supplier's personnel, test all connection arrangements, including possible heat exchangers, at a pressure of ________ bar.

4.2 The Supplier must receive a minimum of one day's notice prior to pressure testing. Pressure testing must be performed during normal working hours.

4.3 A plumber shall provide pressure pump, etc.

4.4 Should it turn out that the system is not installed in accordance with the terms in force, the plumber shall repair the defects and give notification of a new test.

5. Start-up of the System

5.1 The plumber shall, on behalf of the owner of the property, send in to the Supplier a written application for start-up of the system a minimum of ________ day(s) before the start-up.

5.2 Prior to connection, the system is to be cleaned of impurities by flushing with cold water under the supervision of the Supplier.

5.3 Start-up is performed according to the agreement with the Supplier.

5.4 If a system has been either fully or totally emptied of water, the system must not be supplied with water from the Supplier's pipes without special agreement with the Supplier.

7. Alterations

7.1 The Supplier retains the right to make alterations of or additions to these specifications.

Example V

1. Customer Station

The entire system from the customer's shut off valve to the local water system shall be installed and paid for by the customer.

The above system includes:

1. All equipment from the main shut off valve to the water system (primary side). The only exception being the meter that is provided by the Supplier and shall be monitored at the expense of the customer.

2. The heat exchanger system that transfers heat from the primary side to the local heating and cooling system. Water in the distribution network (primary side) and in the local system (secondary system) are separated into two independent systems by a heat exchanger of acceptable design and material to the Supplier.

3. All equipment from the heat exchanger system to the local system.

All above equipment exclusive of the main shut off valve and the meter shall be installed, owned, serviced, and maintained by the customer who is also responsible for all costs incurred.

The Supplier shall at all times have access to make inspection of the above named equipment.

The original design and any future modifications of the customer station between the main shut off valve and the customer's system and including such system shall be in accordance with all local codes and ordinances and approved by the Supplier.

The Supplier shall have the opportunity to inspect the customer station and oversee pressure testing of the piping system.

The customer is responsible for maintaining the room where the main shut off valve and meter are located and for providing lighting. The room shall remain locked at all times.

The equipment on the primary side shall be designed to withstand pressure of bars (atmosphere).

The pressure difference between forward and return pipelines at the main shut off valve is:

Minimum ____________ bar (atmosphere)
Maximum ____________ bar (atmosphere)

Removal of water from the primary side is not permissible without prior permission of the Supplier.

2. Metering

Heat usage is determined through measuring of the number of Btu removed from the water flow. The required metering system shall be installed according to the Supplier's specifications. The metering system is installed on the primary side of the distribution system. The metering system is provided by the Supplier but its cost and installation is the responsibility of the customer. The Supplier shall maintain the metering system and shall have access to the meter at all times.

Metering consists of the circulating heat content and the heat removed (Delta t°F). The delivered heat is defined as the flow times the Delta t°F.

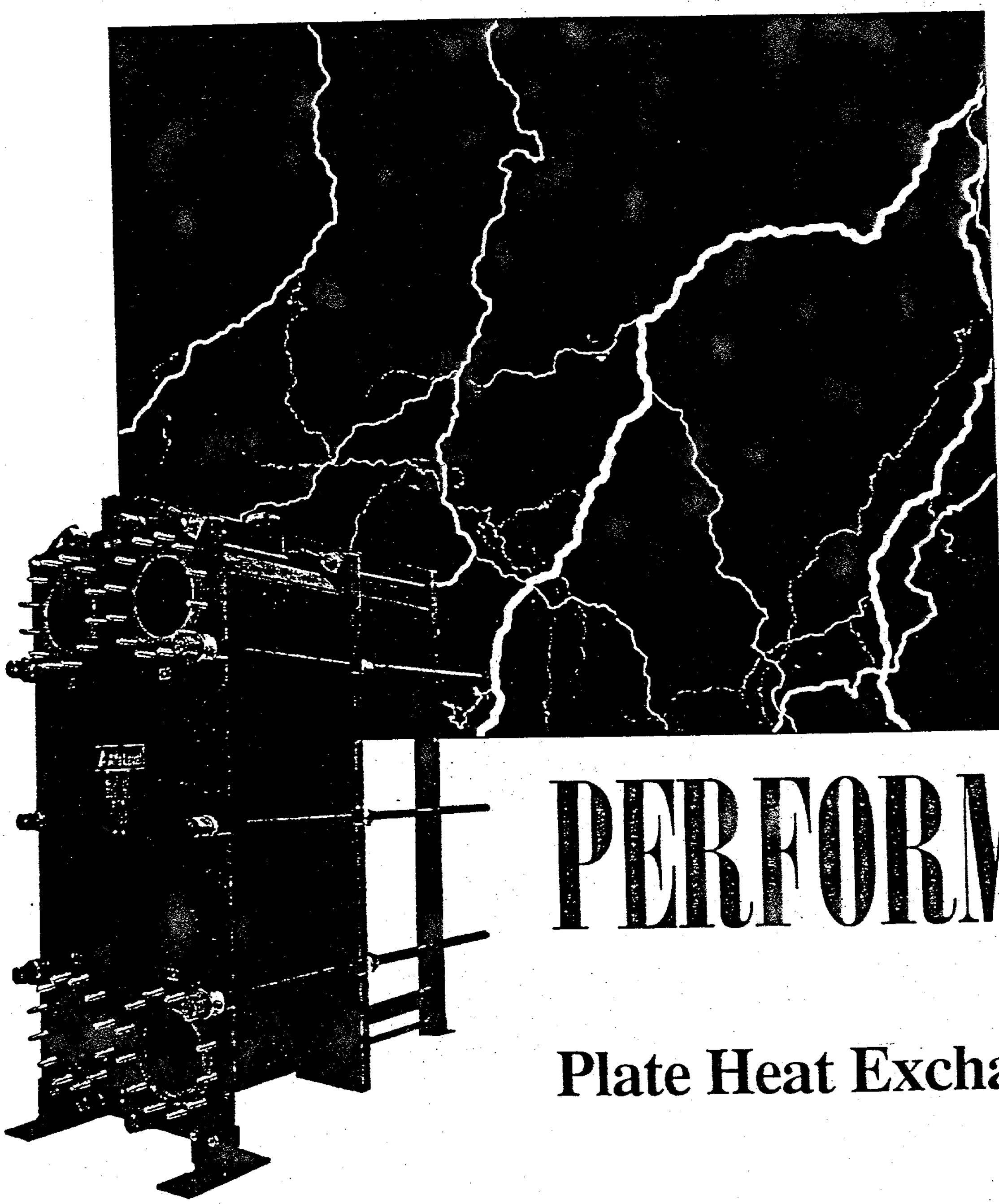
The Supplier's seals on the main valve and meter may be broken only by the Supplier's personnel.

Exhibit A

Plate and Frame Heat Exchanger

Alfa Laval

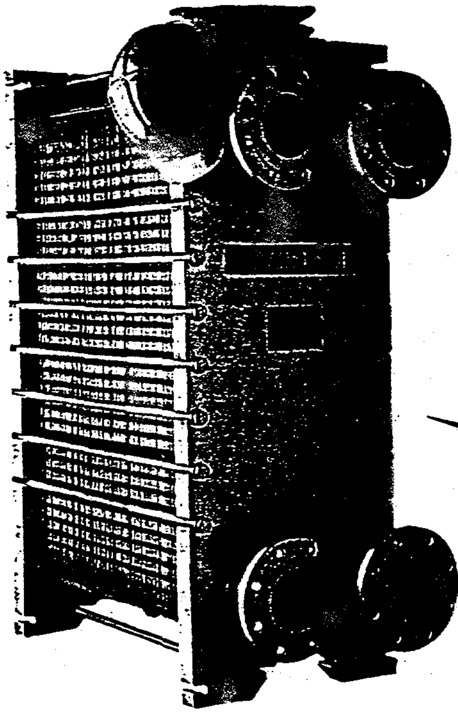
Alfa Laval Thermal



HIGH PERFORMANCE

Plate Heat Exchangers . . . . .

Alfa Laval: The Innovator In

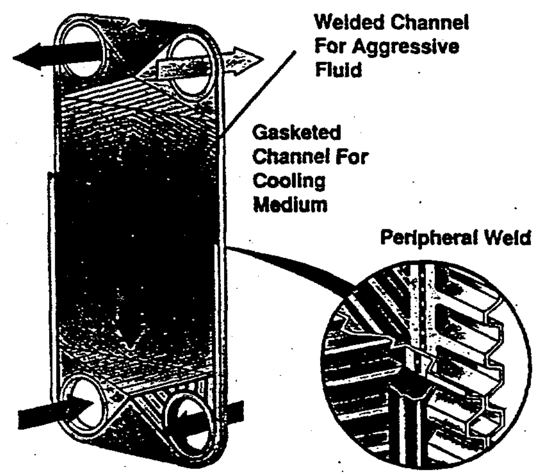


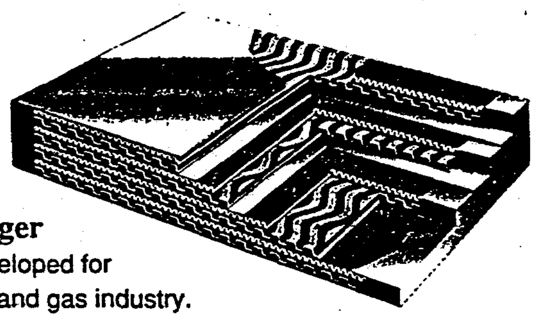
AlfaRex

NEW 100% gasket free, high temperature, high pressure, compact (Alfa Laval Resistant Exchanger) Plate Heat Exchanger. Laser welded. Two dimensional welding eliminates thermal expansion fatigue. Expands temperature and pressure limitations to 650°F and 600 PSIG.

Semi-Welded Plate

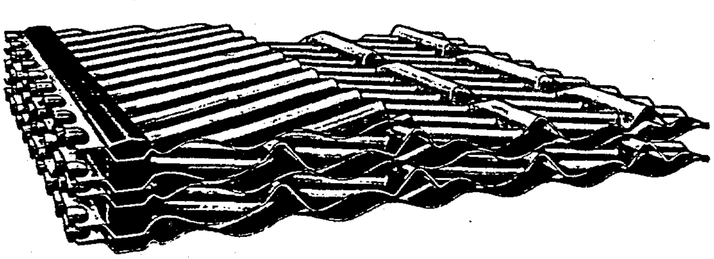
Welded channels for process fluids allow aggressive and difficult fluids to be handled in a plate heat exchanger.





Rolls Laval Heat Exchanger

Specifically developed for the offshore oil and gas industry. Rolls Laval withstands up to 750°F and 7,250 PSIG. It's all titanium material is excellent for direct cooling with seawater.



Wide-Gap Plate

With 5/8" channels free of contact points, this plate is ideal for high viscosity fluids or fluids containing fibers or coarse particles. Each channel has been designed to eliminate bridging of solids in the entrance area.

Double-Wall Plate

Composed of plates pressed simultaneously and laser weldec at the port, it is designed for applications where additional reliability against intermixing is necessary to prevent catastroph Failure of one plate results in a external detection without interleakage. The second wall provides a double barrier bet fluids, satisfying local health coc

Plate Heat Exchanger Technology

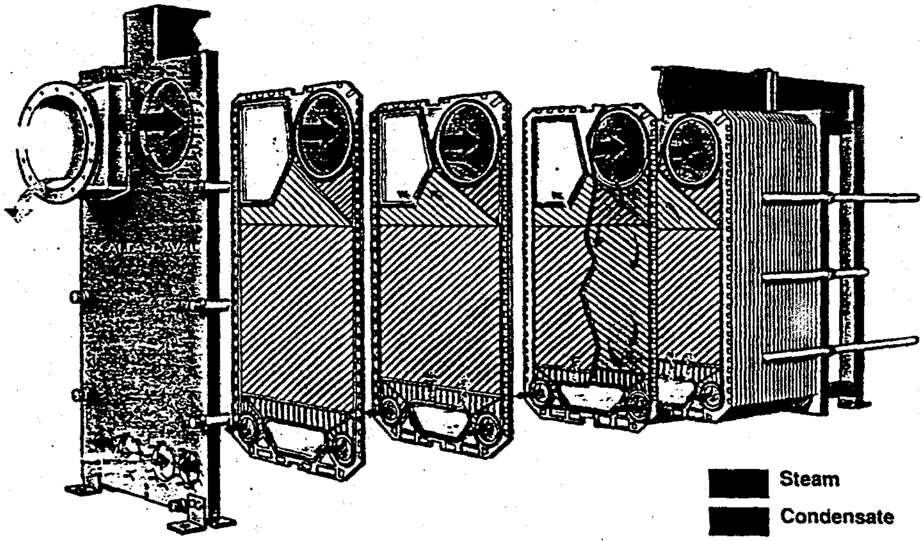
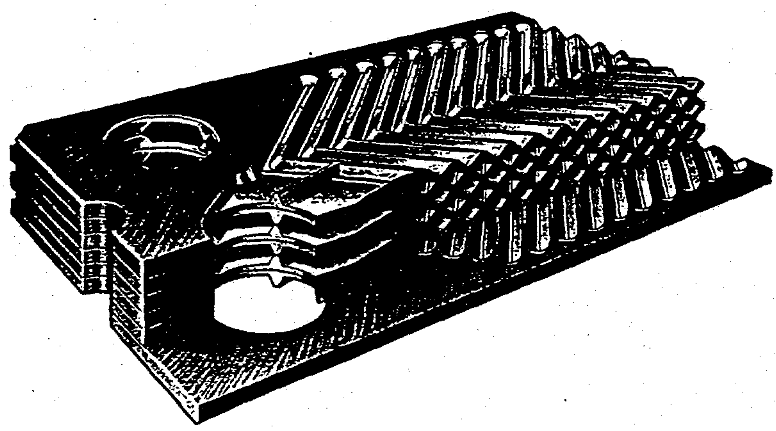


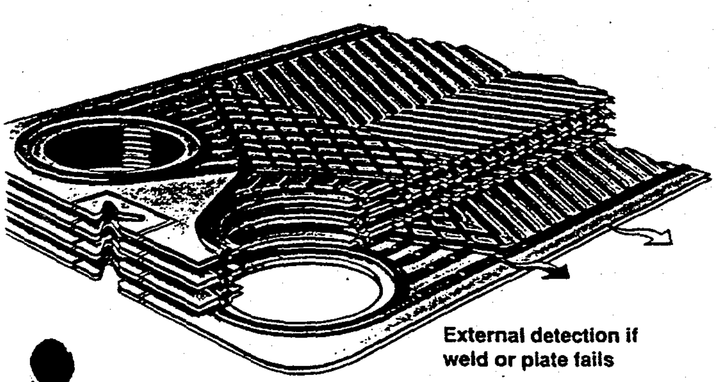
Plate Evaporator/Condenser

Compact and economically efficient, the plate evaporator/condenser replaces conventional large and expensive falling film units. Its deep channels, large ports and laser welding allows vacuum and low pressure evaporation and condensing for both aqueous and organic systems.



Diabon F® Nonmetallic

A composite of fused graphite and fluoroplastic, this unit offers excellent resistance for hydrochloric acid, $AlCl_3$, and other corrosive materials. Unlike traditional graphite, Diabon F® has no porosity or permeability. It resists cracking and breakage during handling and use.



Brazed Units

Using copper or nickel brazing to eliminate gaskets, these compact heat exchangers are perfect for small or packaged applications. Copper brazed units up to 435 PSIG and 435°F, nickel brazed units up to 323 PSIG and 435°F.

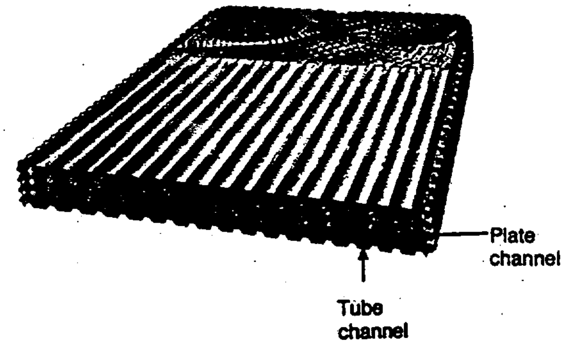
Alfa Laval

Plate heat exchanger innovations for industrial heat transfer duties

Alfa-Laval has been a pioneer in introducing plate heat exchangers tailormade to fit the specialized needs of the chemical process industries and other industrial duties as illustrated by the five newly developed products below. The glue-free gasket systems shown on the next page are other breakthroughs which simplify service procedures and reduce downtime.

The Flow-Flex tubular plate heat exchanger

The Flow-Flex tubular plate heat exchanger is a unique heat exchanger which combines some of the best characteristics of the shell-and-tube heat exchanger with all the advantages of the plate heat exchanger. While the conventional plate heat exchanger is normally best suited for duties with equal flow rates, Flow-Flex can handle asymmetrical duties, i.e. dissimilar flow rates at a ratio of at least 2 to 1. This vibration-free plate configuration makes it especially suitable for low-pressure condensing and vaporising duties and for fibrous and particle-laden fluids.

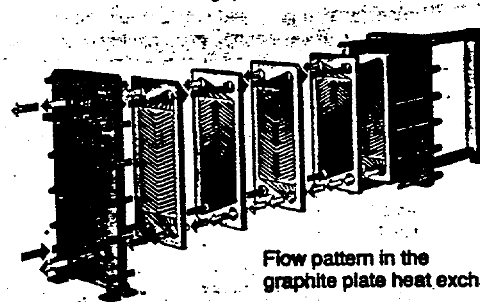


The Wide-gap plate heat exchanger

Alfa-Laval's Wide-gap plate heat exchanger provides a free-flow channel for liquids and products containing fibres or coarse particles or high-viscosity liquids which normally clog or cannot be satisfactorily treated in shell-and-tube heat exchangers. The plate contours provide high product turbulence and high heat transfer efficiency. Compared to the shell-and-tube heat exchanger, this means longer operating periods and up to three times larger heat transfer coefficients.

The Graphite plate heat exchanger

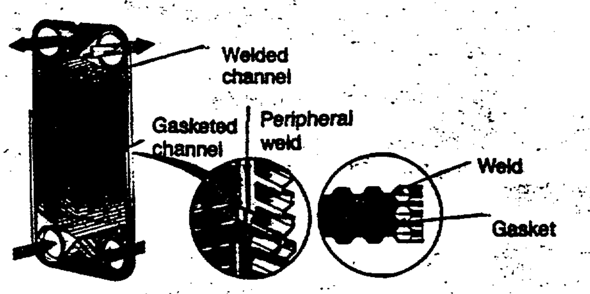
The graphite plate heat exchanger is a heat exchanger with graphite plates developed in cooperation with SIGRI of West Germany for use with media normally too corrosive for exotic materials. The corrosion-resistant properties of Diabon® F100 graphite in combination with the mechanical advantages of the plate heat exchanger extend the performance range of the plate heat exchanger.



Flow pattern in the graphite plate heat exchanger

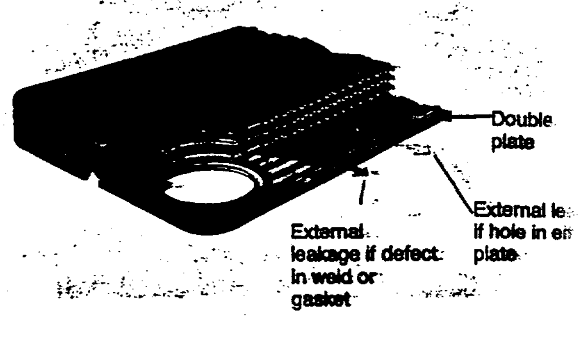
The Twin-plate heat exchanger — the welded plate heat exchanger

The welded plate heat exchanger extends the limits of the traditional plate heat exchanger for handling aggressive media. In duties where gasket material has previously been a limitation, new sealing methods now expand the range of applications formerly reserved for the shell-and-tube heat exchanger and other welded constructions.



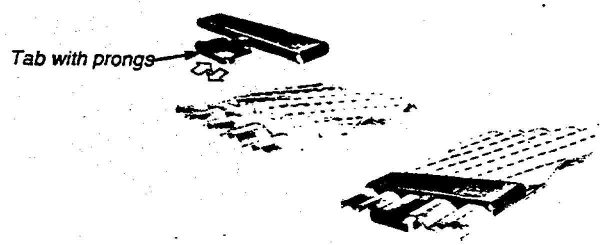
The Double-wall plate heat exchanger

The Double-wall plate heat exchanger is a technical breakthrough for heat exchange for media between which a hostile reaction can occur if the two fluids should mix. The Double-wall plate heat exchanger is therefore a new alternative to traditional heat transfer equipment such as the double-wall shell-and-tube heat exchanger, the triple-tube shell-and-tube heat exchanger, the double-circuit intercooler, and coils for indirect heating.



Alfa-Laval's glue-free gasket systems

Alfa-Laval has two unique glue-free gasket systems — the Clip-on gasket and the Snap-on gasket. Both models, which are designed for heavy-duty industrial applications, perform in the same manner as traditional glued gaskets. They not only simplify service procedures but reduce service downtime.

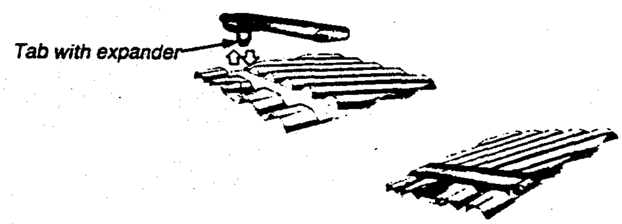


The Clip-on gasket

Alfa-Laval's Clip-on gasket, is attached to the plate with a paper clipshaped tab. Prongs slide around the edge of the plate and hold the gasket securely in place.

The Snap-on gasket

Alfa-Laval's Snap-on gasket simply snaps into place during fitting and snaps out of the groove for regasketing. The Snap-on gasket is attached to the plate by a tab with an expander on its underside. When the expander is inserted through the holes punched in the corrugated edge, it enlarges to hold the gasket securely in alignment in the gasket groove.



Advantages of the glue-free gasket systems:
- simplifies regasketing by eliminating gasket removal procedures such as heating or freezing off gaskets
- eliminates glueing procedures
- makes regasketing possible on-site thereby reducing plant downtime and expense
- reduces unscheduled service shutdowns
- makes regasketing feasible without removing the plates from the frame.

This easy on-site regasketing method facilitates preventive maintenance thereby minimizing unscheduled service shutdowns.

Alfa-Laval — an international thermal engineering company

Alfa-Laval, a worldwide thermal engineering company, have nearly 50 years of experience in designing heat exchangers for such demanding applications as those in the chemical and hydrocarbon processing industries, the nuclear power industry, steelworks, HVAC (Heating, ventilation and air conditioning), mechanical engineering industry and the offshore industry. Practical experience from these industries is put to good use as a background for further developments of the world's widest range of heat exchangers.

Alfa-Laval Thermal is a member of the Alfa-Laval Group, an international engineering organization specializing in thermal and separating techniques.

Today the Alfa-Laval Group employ 16 000 people in 70 companies in 30 countries and in addition have a network of sales agents which means that Alfa-Laval have business connections in a total of 125 countries throughout the world. Forty-five factories in 30 countries manufacture and supply Alfa-Laval products to customers in all corners of the globe. Fourteen of these are manufacturing or assembly facilities for the plate heat exchanger. Service facilities for the plate heat exchanger are located in more than ten countries covering the continents of the world.

After-Sales service from one of these service centres is an additional form of security offered to the customer. Contact your nearest representative for consultation and additional material. Should your representative not be familiar with precisely your problem, he has only to call upon the experience and skill of one of his colleagues in the Alfa-Laval Group encircling the globe.

These innovations are patented or have patents pending in many countries.

Alfa Laval

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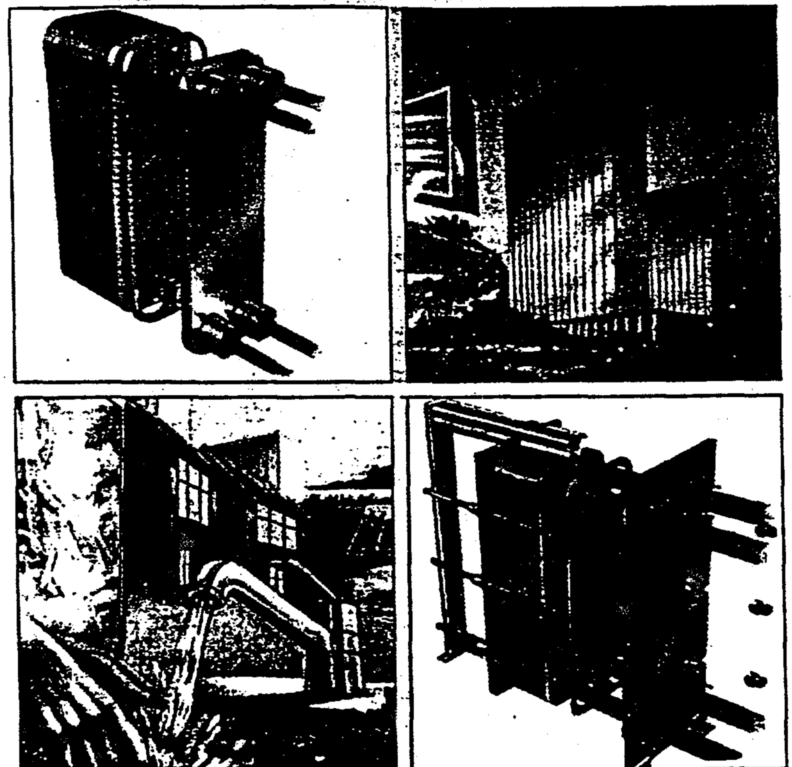
Alfa Laval



Heating Applications for Plate Heat Exchangers in HVAC

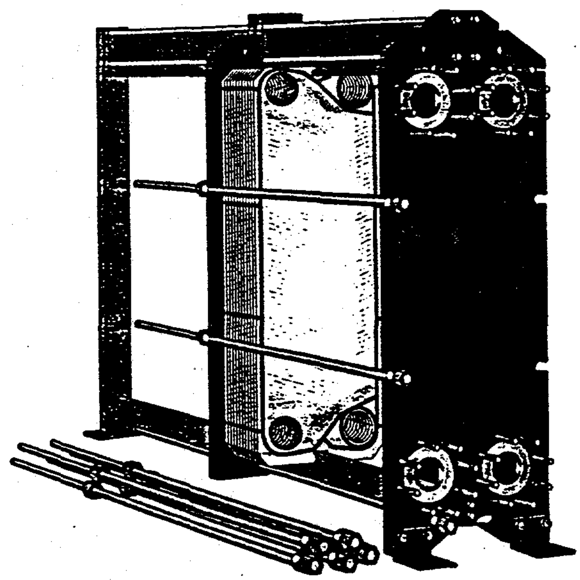
- Heating systems in general
- Market description
- Tap water heating with oil or gas boilers
- Swimming pool heating
- Tap water heating with solar energy
- Normal types of Alfa Laval HEs
- Alfa Laval as your supplier

Normal Types of Alfa Laval Heat Exchangers

Gasketed Plate Heat Exchangers

Plate material:	Stainless steel AISI 316
Gaskets material:	Nitrile (max. 110 °C)
	EPDM (max. 130 °C)
Max. design pressure:	25 bar

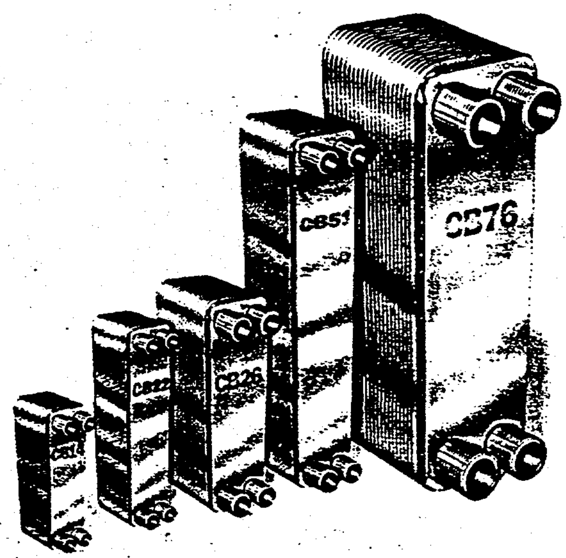
The units can be opened for service and cleaning which is important if your water has a very high calcium content.



Brazed Plate Heat Exchangers

Plate material:	Stainless steel AISI 316
Brazed sealing mtrl:	Copper
Max. design temp.:	225 °C
Max. design pressure:	30 bar

The unit is extremely compact as it has no bolts or frame parts. Since it cannot be opened, it is cleaned, if necessary, with circulating chemicals.



Double-Wall Plate Heat Exchanger

Special requirements for tap water are set up in the EUREAU document issued by the "Union of Water Supply Associations of the Countries of the European Community".

Tap water is to be classified as general food. Hence it should be separated from the heating source fluid by a secondary circuit or double wall. Some European countries (notably the Netherlands) have enforced this.

Alfa Laval Thermal supplies a double-wall plate heat exchanger with no risk of internal leakage. The double-wall plate consists of two identical plates welded together around the portholes.

The channels formed by assembling double-wall plates are then sealed by gasket material as mentioned above. The double-wall fulfils the requirements and ensures absolute security.

Advantages of Using a Plate Heat Exchanger

High Comfort and Economy

A plate heat exchanger solution offers instantaneous water. No waiting time to heat up the tap water is required.

Compact Size

With or without an accumulator tank, a system with a plate heat exchanger typically requires 50-70 % less floor space than a traditional tank and coil type system. The most compact solution is to use a brazed heat exchanger.

Simple Installation

The rectangular plate heat exchangers are delivered with fixtures for mounting on a wall, or with feet or frames for standing on the floor. The four connections face the same direction and are placed on the front plate for easy installation.

The weight is low and the hold-up volume very small, which reduces the foundation to a minimum.

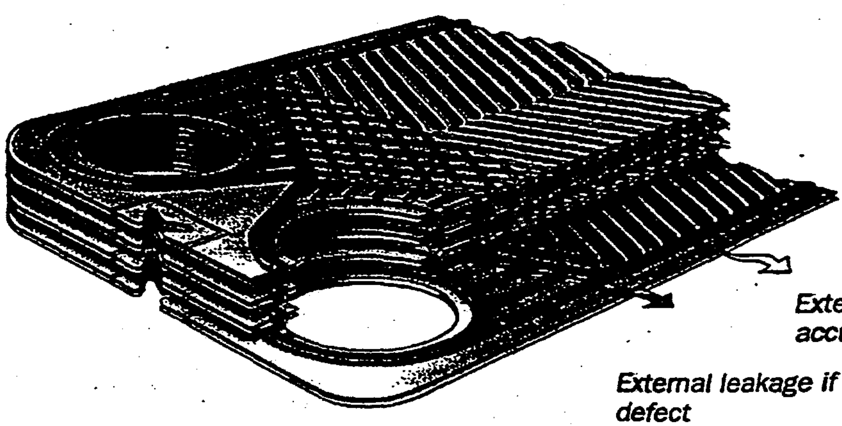
Long Lifetime

The risk of scaling is reduced to a minimum by the high degree of turbulence. Plates of stainless steel are fully resistant to corrosion. If there is a need for opening and cleaning, 100 % of the surface is accessible simply by removing the tightening bolts.

If necessary, the top-quality rubber gaskets can be replaced quickly and easily since they are the Alfa Laval glue-free "Clip-On" type.

Flexibility

If the heating need changes in the future, the plate heat exchanger can easily be redesigned to meet the new requirements. The new requirements can be met by adding some extra plates, and no changes in the piping are needed.



Absolute securtity is obtained with Alfa Laval's unique Double-Wall Plate Heat Exchanger

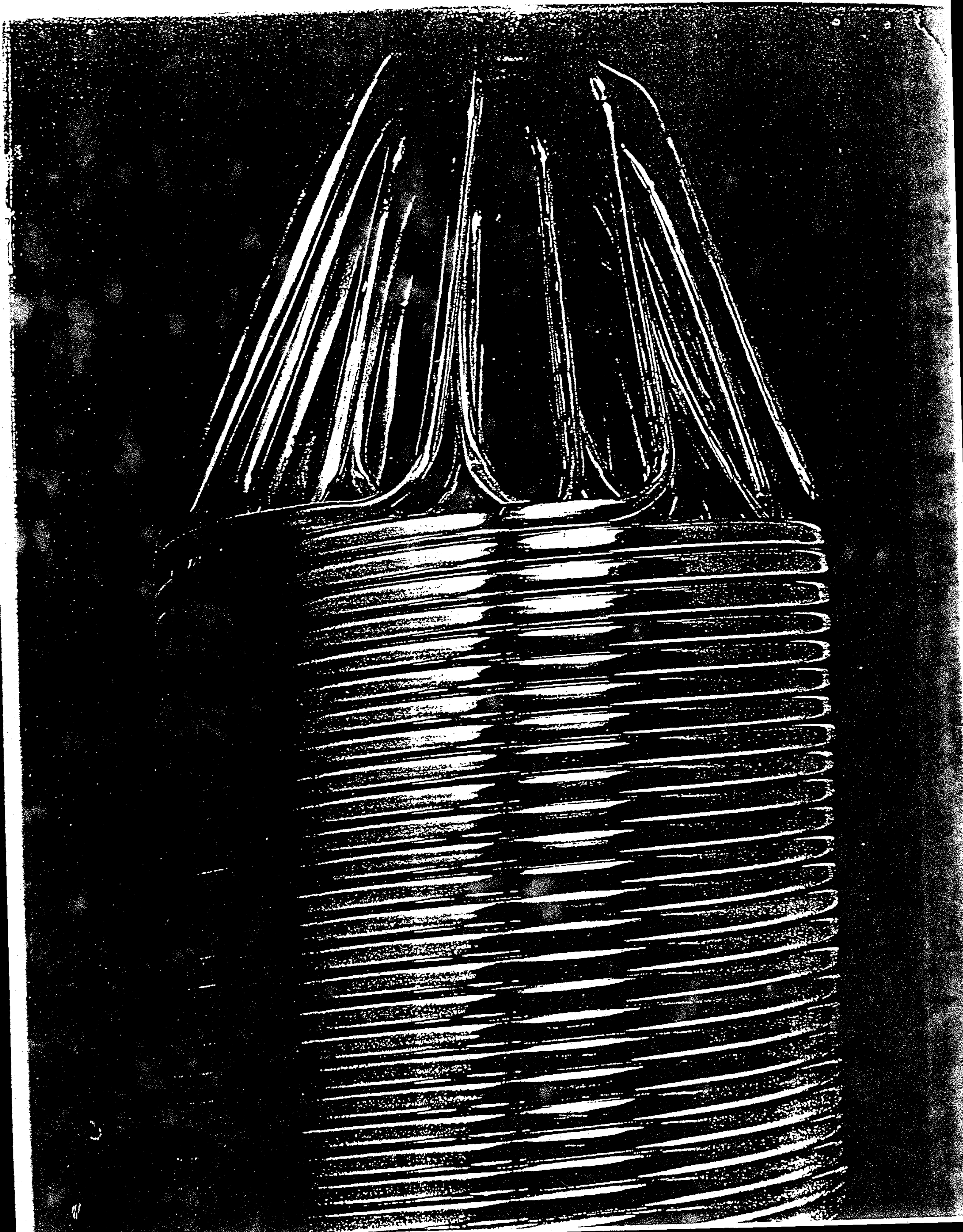
Exhibit B

Shell and Coil Heat Exchanger

THE SHELL

Shell and coil heat exchangers are designed to be used with different media, including: Water-Water; Oil-Water; Oil-Steam; Steam-Water. ELGE shell and coil heat exchangers feature an all welded and brazed construction. The pressure vessel is made from carbon steel, and is fitted with hemispherical heads.

The absence of mechanical joints and gaskets provides for low maintenance and long life. This unique design concept is proven by more than thirty years of experience and the many thousands of heat exchangers in operation.



ELGE Shell & Coil Heat Exchangers
Type R and Type S - Technical Description

Applications

The Type R and Type S shell and coil heat exchangers are suitable for a wide range of applications, including:

- Space Heating and Cooling
- Process Applications
- Domestic Hot Water
- Heat Recovery

Heat Transfer Media

The Type R and Type S shell and coil heat exchangers are designed to be used with different medias, including:

- Water - Water
- Oil - Water
- Oil - Steam
- Steam - Water

Battery

The battery is manufactured from drawn, smooth, spiral wound cooper tubes with an oval cross section. The tubes are separated by spacer elements which form channels with uniform flow areas. The copper tubes are joined to a collection chamber with low flow resistance.

Pressure Vessel

The pressure vessel is made from carbon steel, and is fitted with carbon steel hemispherical heads.

Insulation

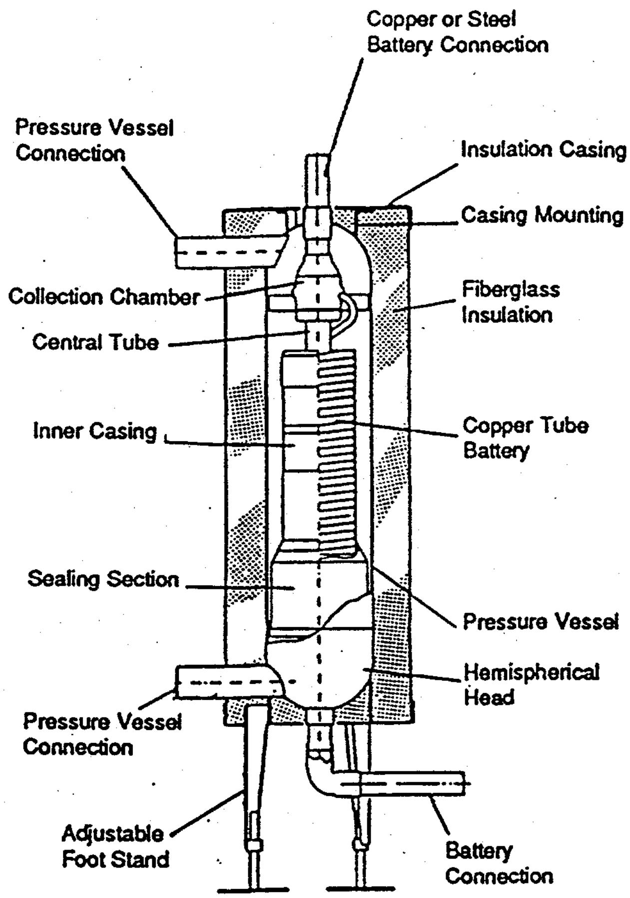
The heat exchangers are insulated with fiberglass, and covered with an aluminum jacket. The insulation can be easily removed to facilitate inspections of the pressure vessel.

Pressures and Temperatures

	Battery	Pressure Vessel
Design Pressure, psig	250	250
Test Pressure, psig	325	325
Design Temperature, F	400	400

Pipe Connections

Type R - All connections are made of A53, sch 40 carbon steel, and can be supplied with weld ends or class 250 flanges.



Type S - The pressure vessel connections are made of A53, sch 40 carbon steel,and can be supplied with weld ends or flanges. The battery connections are copper plain end for soldering.

Foot Stand

The heat exchangers are delivered with adjustable feet for vertical installation.

ASME

The shell and coil heat exchangers meet the requirements of the ASME boiler and pressure vessel code, and are delivered with an ASME code symbol stamp. The data plate is permanently attached to the pressure vessel. Each heat exchanger is supplied with a manufacturer's data report.

ELGE

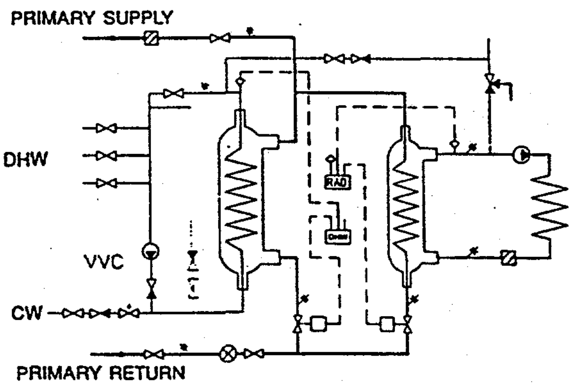
ELGE

ELGE Tubular Heat Exchangers

Types R, R2, S and S2
Connection Circuits, Examples

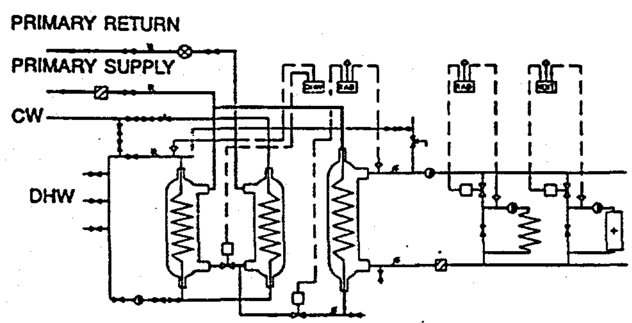
SINGLE STAGE CONNECTION (PARALLEL CONNECTION)

Heat exchanger for domestic hot water (DHW) and radiators (RAD).
For small properties in areas where this type of connection is approved.



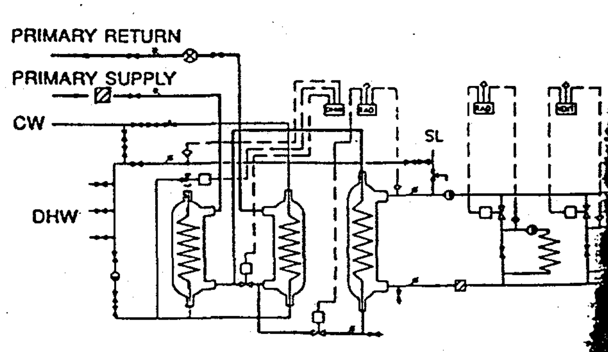
2 STAGE CONNECTION

Heat exchangers for domestic hot water (DHW) and radiators (RAD).
For use with hard water or water containing other types of impurity which may result in precipitation in the DHW heat exchanger.



3 STAGE CONNECTION

Heat exchangers for domestic hot water (DHW) and radiators (RAD).
For use in areas with soft water.

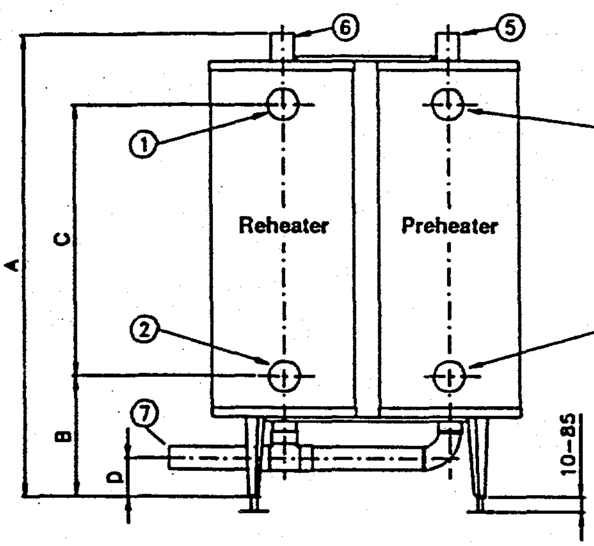


ELGE

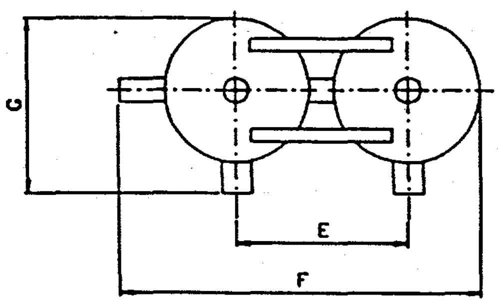
ELGE Tubular Heat Exchangers

Type S2, Dimensions

for domestic hot water systems and
2 or 3 stage connection



1. Primary Supply
2. Primary Return, reheater
3. Primary Supply, preheater
4. Primary Return
5. Cold Water
6. Domestic Hot Water
7. Preheated Domestic Hot Water for 3 stag connection, Domestic Hot Water Centre 2 stage connection.



Type	A	B	C	D	E	F	G	Connections 1 2 3 4 DN	Connections 5 6 7 Ø Dy	Weight (kg)
S2-11 and S2-21	1105	279	678	144	325	674	346	40	35	70/80
S2-12 and S2-22	1215	279	788	144	325	674	346	40	35	80/90
S2-13 and S2-23	1345	279	918	144	325	674	346	40	35	90/100
S2-31 and S2-41	1156	287	706	121	365	753	386	50	42	100/110
S2-32 and S2-42	1266	287	816	121	365	753	386	50	42	110/130
S2-33 and S2-43	1396	287	946	121	365	753	386	50	42	120/150
S2-51 and S2-61	1260	355	716	165	430	880	451	65	54	170/190
S2-52 and S2-62	1370	355	826	165	430	880	451	65	54	190/220
S2-53 and S2-63	1500	355	956	165	430	880	451	65	54	220/260
S2-71 and S2-81	1383	365	808	119	500	1037	522	80	70	240/300
S2-72 and S2-82	1493	365	918	119	500	1037	522	80	70	320/360
S2-73 and S2-83	1623	365	1048	119	500	1037	522	80	70	380/420

Dimensions in mm.

Alternative

Two single S-XX can be used instead of one type S2-XX.

Advantages:

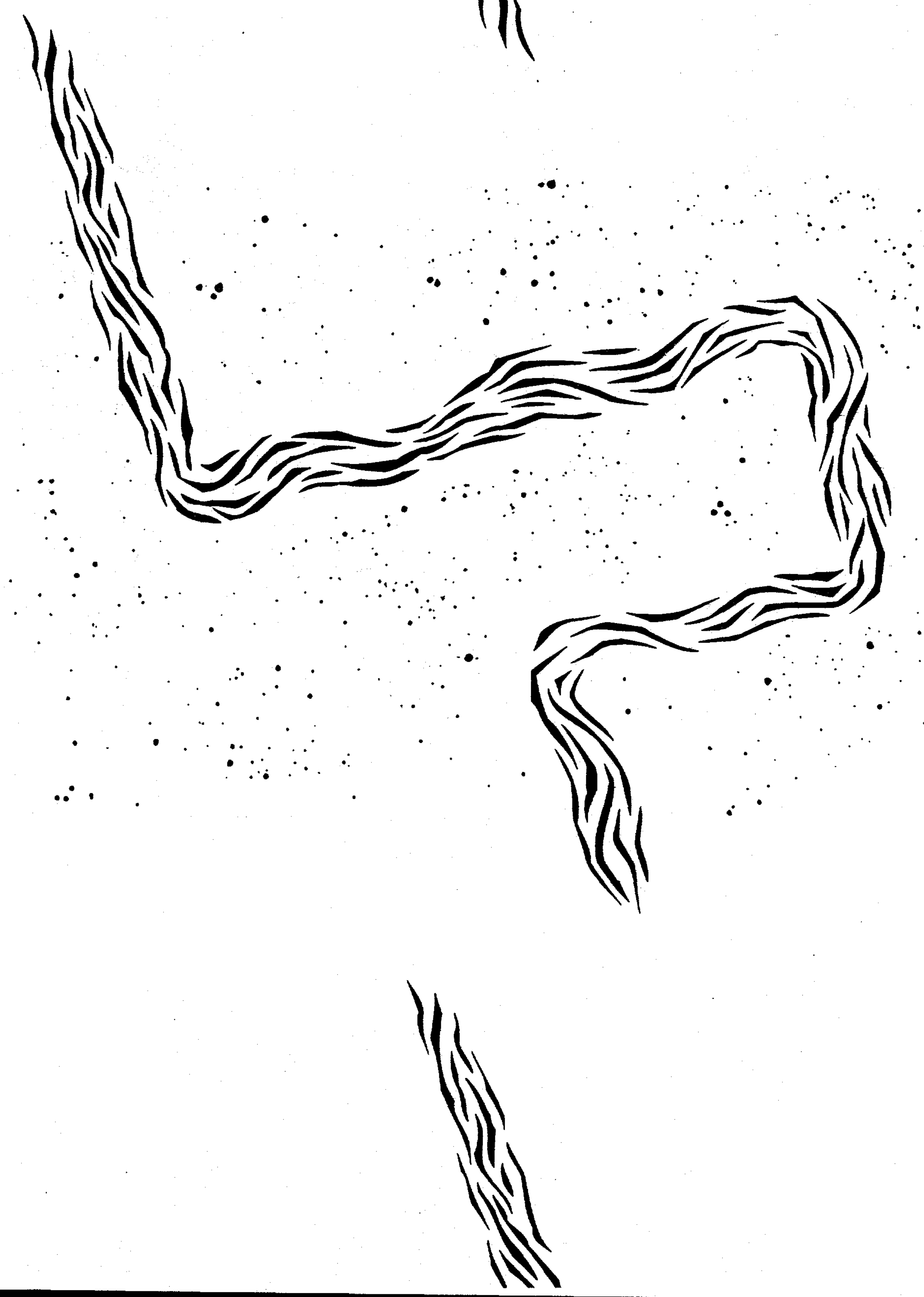
- Simpler mounting of the primary control valve.
- Easier transportation and installation.

Exhibit C

Heat Transfer Fluids

Engineering and Operating Guide

for DOWFROST and DOWFROST HD
Inhibited Propylene Glycol-based Heat Transfer Fluids



INTRODUCTION

This guide provides basic product performance information, engineering data, and operating guidelines for DOWFROST* inhibited propylene glycol-based heat transfer fluids. Included in the guide are: a brief introduction to DOWFROST fluids, typical product specifications, system design and preparation guidelines, glycol concentration and dilution water quality information, plus detailed engineering data including density, viscosity, specific heat and thermal conductivity. If you would like additional product information or specific engineering or operating assistance, call Dow toll free: 1-800-447-4369, Extension DOWFROST.

Where to use DOWFROST propylene glycol-based fluids

Solutions of DOWFROST propylene glycol-based fluids are widely used for secondary cooling and heating applications, for freeze and burst protection of pipes, and for various deicing, defrosting, and dehumidifying applications. They contain specially formulated packages of industrial inhibitors that help prevent corrosion. Specific applications for these fluids include:

- HVAC system freeze/burst/corrosion protection
- Immersion freezing
- Cooling liquid foods
- Packaging carbonated beverages
- Fermentation cooling
- Refrigeration coil defrosting
- Cold room dehumidifying
- Conveyor roller defrosting
- Process cooling
- Process heating
- Waste heat recovery
- Air preheating
- Solar heating
- Sidewalk snow melting systems
- Refrigeration warehouse floor heating

Trademark of The Dow Chemical Company

Choosing between propylene glycol and ethylene glycol fluids

In addition to DOWFROST propylene glycol-based fluids, DOWTHERM* ethylene glycol-based fluids are also available. There are two major differences between propylene and ethylene glycol fluids: viscosity and toxicity. Ethylene glycol-based fluids are less viscous than propylene glycol-based fluids. Therefore, they generally provide superior heat transfer efficiency and better low temperature performance and are preferred for most heat transfer applications. However, in applications where toxicity is a concern, propylene glycol fluids are used because of their low acute oral toxicity vs. the moderate acute oral toxicity of ethylene glycols. Examples include applications where contact with drinking water is possible, food processing applications where accidental contact with food or beverage products could occur, and applications in localities where propylene glycol use is mandated by law. For additional toxicity information, see the discussion on page 42 of this brochure and request Material Safety Data (MSD) sheets, available from Dow.

This guide provides information about DOWFROST propylene glycol-based fluids only. For additional information about DOWTHERM ethylene glycol-based fluids, call 1-800-447-4369 and request Form No. 180-1190, "Engineering and Operating Guide for DOWTHERM SR-1 and DOWTHERM 4000 Inhibited Ethylene Glycol-based Heat Transfer Fluids."

Regulatory Status of DOWFROST Fluid

DOWFROST inhibited propylene glycol-based fluid is listed as chemically acceptable by the U.S. Department of Agriculture (USDA) for both defrosting refrigeration coils and for immersion freezing of wrapped meats, poultry and meat products in food processing plants operated under federal inspection. The FDA clears only individual ingredients, not proprietary products (trademarks). The two ingredients in DOWFROST fluid are generally recognized by the FDA as safe food additives under parts 182 and 184 of the Food Additive Regulations. The regulation for propylene glycol is 21 CFR 184.1666; for dipotassium phosphate, 182.6285. The propylene glycol and dipotassium phosphate in DOWFROST fluid meet the requirements of these regulations. Grade A dairies and meat packing establishments sometimes require a letter certifying the appropriate use and quality of DOWFROST fluid. Such a letter, along with copies of the acceptance letter from the USDA and a statement of FDA compliance, will be provided to Dow customers on request.

For applications where there is no chance of accidental contact with food or beverage products, and where there is no possibility of incidental contact with drinking water, DOWTHERM ethylene glycol-based fluids are generally used because of their greater heat transfer efficiency and superior low temperature performance. (Request Form No. 180-1190, "Engineering and Operating Guide for DOWTHERM SR-1 and DOWTHERM 4000 Inhibited Ethylene Glycol-based Heat Transfer Fluids.")

Preparing Systems for the Addition of DOWFROST or DOWFROST HD Heat Transfer Fluid

Existing systems

In existing systems, all lines and materials should be cleaned and flushed thoroughly before charging the system with DOWFROST fluid. This is especially important if fluid previously in the system is incompatible with the new inhibited glycol fluid. A Dow technical service representative can help you determine the compatibility of other fluids with DOWFROST and DOWFROST HD heat transfer fluids.

If a fluid containing silicates (such as automotive antifreeze) was previously used, it may be necessary to clean silicate residues from the system.

It is also important to remove all rust, scale, and sediment in the system. Traces of chloride should be removed—whether from old fluid or residue from acid cleaner—because chlorides can contribute to corrosion. For large systems, or systems where corrosion is already evident, consult a professional industrial cleaning organization. For heavily fouled or corroded systems, an optimum cleaning procedure includes the use of an inhibited acid followed by neutralization and phosphatization. This procedure is quite involved and should be done by a company experienced in industrial cleaning. If chemical cleaning is used, it is important that all traces of the cleaning agent be removed, and the system be thoroughly flushed with water.

New systems

New systems are typically coated with oil, grease or a protective film during fabrication, storage, or construction. Dirt, solder flux, and welding and pipe scale can also cause problems. Therefore, thorough cleaning of new systems is recommended. A solution of 1 to 2 percent trisodium phosphate can be used with water for flushing the system. System volume can be calculated during this stage by metering in the initial fill of the system, or by chemical analysis of cleaning chemicals after known quantities are introduced into the system.

How DOWFROST Inhibited Fluids Protect Against Corrosion

DOWFROST and DOWFROST HD glycol-based coolants contain specially formulated industrial inhibitor packages that are effective in preventing corrosion of metals commonly used in HVAC, food processing, and process heat transfer equipment. These inhibitors prevent corrosion of metals in two ways.

First, they passivate the surface of metals, reacting with the surface to prevent acids from attacking it. Unlike inhibitors used in some other fluids, Dow inhibitors perform this passivation process without fouling heat transfer surfaces. The inhibitors in automotive antifreeze, on the other hand, contain silicates that coat heat transfer surfaces with a thick silicate gel that reduces heat transfer.

Second, the inhibitors in DOWFROST fluids buffer any acids formed as a result of glycol oxidation. All glycols produce organic acids as degradation products. This degradation is accelerated in the presence of oxygen and/or heat. Left in solution, such acids lower pH and contribute to corrosion. Properly formulated inhibitors such as those in DOWFROST fluids neutralize these acids.

The standard ASTM D1384 corrosion test is a screening test that measures the relative corrosion protection provided by different solutions on standard metals under standard test conditions. The data in Table 6 show relative corrosion rates for DOWFROST and DOWFROST HD fluids compared to uninhibited propylene glycol and plain water. The data indicate that solutions of DOWFROST fluids fall well within the generally accepted corrosion limits considered adequate under this test. Rates in excess of 0.5 mpy (2.5 mpy for aluminum) are generally evidence of inadequate corrosion protection. (Since it is only a screening test, ASTM D1384 may not be indicative of performance in an actual system.)

The presence of excessive amounts (>25 ppm) of contaminants such as chlorides, sulfates, and/or ammonia could contribute to system corrosion not evident in these tests. For example, excessive concentrations of chloride ions will result in the formation of iron chloride. With any available oxygen, iron chloride will react to form iron oxide, which is insoluble. The resulting deposition of precipitant forms an area where under-deposit corrosion can occur. This corrosion will be further accelerated by the presence of chlorides and cannot be eliminated through the use of a non-chromate-based inhibitor. This underscores the importance of dilution water quality, discussed on page 9 of this guide.

Table 6—Corrosion Test Results/Weight Loss in Milligrams (Mils Penetration Per Year)

	Water	Propylene Glycol	DOWFROST Fluid	DOWFROST HD Fluid
Copper	2 (0.08)	4 (0.16)	3 (0.12)	1 (0.04)
Solder	99 (3.14)	1095 (34.7)	1 (0.03)	2 (0.06)
Brass	5 (0.23)	5 (0.20)	4 (0.16)	2 (0.08)
Mild Steel	212 (9.69)	214 (9.80)	1 (0.04)	1 (0.04)
Cast Iron	450 (21.2)	345 (16.2)	3 (0.15)	1 (0.05)
Aluminum	110 (13.2)	15 (1.80)	+2 (+0.26)	+3 (+0.36)

Samples with a "+" showed weight gain.

ASTM D1384—*190°F for 2 weeks. 30% by volume glycol, air bubbling.*

Safety, Handling, Storage, and Disposal of DOWFROST Propylene Glycol-based Fluids

Toxicology

For complete product toxicological information for DOWFROST fluids, request Material Safety Data (MSD) sheets from Dow. The MSD sheets provide the most up-to-date health and safety considerations related to the use of these products and should be consulted prior to use of the products.

Storage

Storage of DOWFROST glycol-based heat transfer fluids presents no unusual problems. The materials do not readily solidify, are low in toxicity, have high flash points, and can be handled without posing a hazard to health. As a precaution, however, sparks or flames should be avoided during transfer or processing operations because undiluted glycols can be ignited. Tank truck shipments can be emptied into storage tanks or clean drums.

Tank storage

Ordinary steel tanks are normally satisfactory for storage of DOWFROST fluids. However, during extended storage, slight discoloration may occur from iron contamination. Rusting may occur in the vapor space because there is no inhibitor where condensation occurs and oxygen is present. This problem can be minimized by closing any vent to the tank to limit oxygen intake. If this is not possible, see page 11 for a discussion of coatings suitable for protection of vapor space in tanks.

Insulation and heat are required for storage of DOWFROST fluids at low temperatures. This will prevent freezing or pumping problems due to high viscosity. Maintaining temperatures above 10°F is usually sufficient to avoid such problems.

Drum storage

DOWFROST fluids may be stored in the drums in which shipment is made. Because glycols are hygroscopic, it is important that the drum cap be replaced tightly after each withdrawal to keep the material in the drum from absorbing water. Drums should be stored inside a heated building when temperatures below 10°F are anticipated. This will assure that the glycol is in a liquid form when needed.

Environmental considerations

The biochemical oxygen demand (BOD) for propylene glycols approaches the theoretical oxygen demand (ThOD) value in the standard 20-day test period. This indicates that these materials are biodegradable and should not concentrate in common water systems. The possibility of spills in lakes or rivers, however, should be avoided, since rapid oxygen depletion may have harmful effects on aquatic organisms. Extensive testing of the effects of propylene glycol on aquatic organisms has shown the material to be practically non-toxic (LC 50 > 100 mg/L) with LC 50's ≥ 10,000 mg/L for fathead minnow, rainbow trout and Daphnia magna.

Table 16—Biochemical Oxygen Demand for Propylene Glycol

BOD	Parts Oxygen/Parts Propylene Glycol
5 day	1.12
10 day	1.22
20 day	1.42
ThOD	1.68

Spill, leak and disposal procedures

Using appropriate safety equipment, small spills may be soaked up with common absorbent material. For large spills, the fluid should be pumped into suitable containers located in diked areas. Residual material should be cleaned up with water. Concentrate can be handled according to local, state, and federal regulations.

Salvage

Some distributors of DOWFROST fluids are equipped to reclaim and/or dispose of spent or contaminated fluids. Occasionally, where regulations permit, diluted spent fluids that are not otherwise contaminated can be disposed of in local sewage treatment facilities, provided those facilities are advised and prepared for such disposal in advance. Aerobic bacteria easily oxidize the fluids to carbon dioxide and water within the usual 20-day test period. The Dow Chemical Company does not normally provide a disposal or reprocessing service for spent or contaminated glycol-based fluids.

For More Information, Request These Free Thermal Fluid Evaluation Tools

To receive more information about Dow heat transfer fluids and fluid applications, just call 1-800-447-4369 and request the appropriate brochure listed below:

- Engineering and Operating Guide for DOWTHERM SR-1 and DOWTHERM 4000 Inhibited Ethylene Glycol-based Heat Transfer Fluids, Form 180-1190
- DOWTHERM SR-1 and DOWFROST Fluids, Form 180-1252
- Glycols for HVAC applications, Form 180-1263
- Fluid specifications for HVAC, Forms 180-1272, 3, 4, 5
- HVAC Mechanical Contractors' Guide, Form 180-01303
- Glycols for food processing applications, Form 180-1112

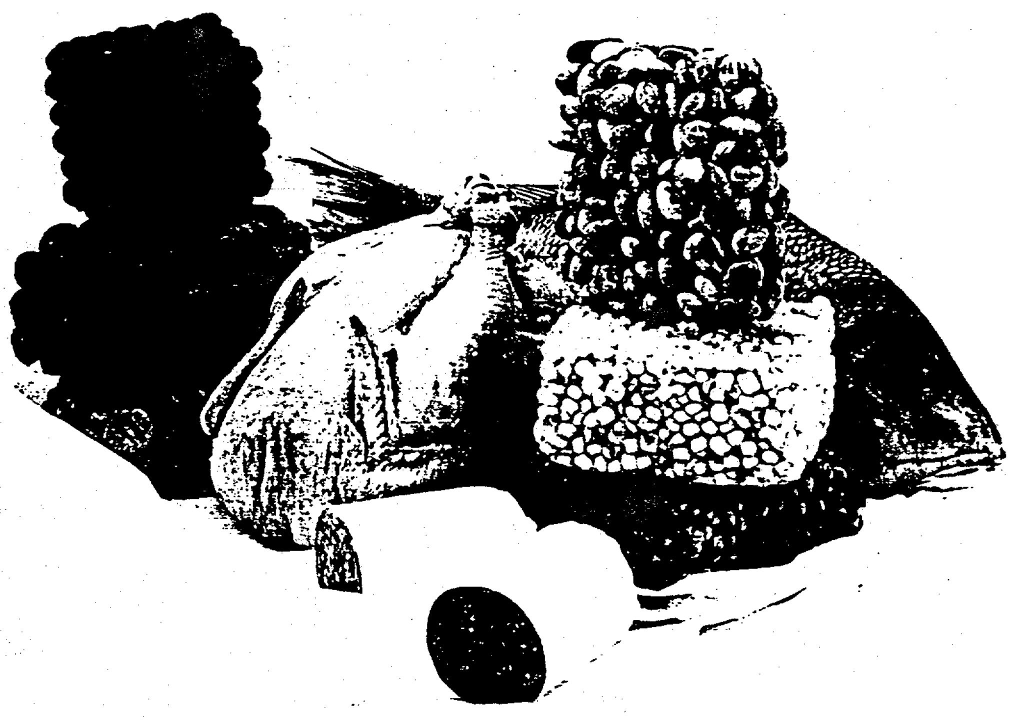
Also ask about these additional engineering tools:

FLUIDFILE software program: This menu-driven, IBM compatible data diskette displays and prints engineering properties of DOWTHERM and DOWFROST glycol-based fluids based on your operating temperature and glycol concentration input. The program also calculates fluid film coefficient and pressure drop based on your operating conditions.

HVAC FOCUS newsletter: Receive this informative newsletter three times each year to stay abreast of the latest information on HVAC system design and operation.

DOWFROST and DOWTHERM SR-1

Inhibited glycol heat transfer fluids
for food industry applications



DOWFROST and DOWTHERM SR-1

Applications and advantages of inhibited glycol fluids in the food industry

Inhibited glycol heat transfer fluids are widely used in the food industry for chilling and freezing food and beverage products. These applications include immersion freezing, cooling liquid foods and fermentation cooling. Inhibited glycols are also used to defrost equipment and dehumidify facilities, with specific applications including refrigeration coil defrosting and humidity control in meat packing operations.

Two Dow heat transfer fluids offer particular utility in food industry applications: DOWFROST* inhibited propylene glycol and DOWTHERM* SR-1 inhibited ethylene glycol. This brochure details the advantages of glycol-based heat transfer fluids, describes the physical and performance properties of Dow inhibited glycol fluids, and highlights some of their many food industry applications.

Why inhibited glycols are the preferred heat transfer fluids in the food industry

Inhibited glycol fluids have successfully demonstrated their ability to upgrade process efficiency, extend equipment life, and improve overall economy while contributing to greater system cleanliness and safety. The following characteristics explain the preference glycols have gained in the food industry.

- The acute oral toxicity of propylene glycol is very low, similar to glycerin. Ethylene glycol is of moderate acute oral toxicity.
- Glycols provide good heat transfer ability and freeze protection with low volatility.
- Properly formulated with inhibitors, glycol fluids combat costly corrosion in heat transfer systems.
- Glycols are practically odorless and colorless, although they are sometimes dyed for easy detection of system leaks.
- Glycol/water solutions (up to 80 percent glycol) are not considered flammable; they have no flash points when tested under the Tag closed cup method.

Why alternative heat transfer technologies fall short

The major applications for inhibited glycol heat transfer fluids in the food industry fall into two broad categories: chilling/freezing of food and beverage products, and defrosting/dehumidifying of equipment and facilities. Alternative heat transfer technologies all have serious drawbacks in these applications.

Plain water. Plain water is effective only at temperatures above 33°F, making it unsuitable for freezing applications and too warm for many chilling processes. Plain water is also a poor choice for chilling/freezing applications due to its corrosivity.

Uninhibited glycols. "Straight" glycols oxidize in the presence of air, leading to system corrosion. This makes them unsuitable for many chilling/freezing and defrosting/dehumidifying applications.

Inhibited brines. These brines are costly to operate in chilling/freezing and in defrosting/dehumidifying operations because their sodium chromate or dichromate inhibitors require frequent analysis and adjustment. If the proper inhibitor level is not maintained, corrosion of metals is likely. The need to replace fluid frequently increases system downtime. Plus, the toxicity of chromate inhibitors makes these fluids unacceptable for use near food products and can create waste disposal problems.

Uninhibited brines. While sometimes used in chilling/freezing as well as in defrosting/dehumidifying operations, uninhibited brines are potentially corrosive to metals exposed to air. Plus they require frequent analysis due to their rapid dilution. These brines cannot be economically regenerated, so operating costs are higher.

Alcohol is sometimes used in defrosting/dehumidifying operations but it is flammable and volatile.

Other defrosting methods and processes—such as hot air/gas, electric and air-dry coil defrosting—consume a great deal of energy, are expensive to operate, interrupt production, and warm cold storage areas. And room air defrost methods require equipment to be shut down while room air melts frost.

*Trademark of The Dow Chemical Company

DOWFROST and DOWTHERM SR-1

Inhibited glycol fluids are the answer to important food industry heat transfer needs

DOWFROST and DOWTHERM SR-1 fluids offer specific advantages in a variety of chilling/freezing and defrosting/dehumidifying applications. These advantages include: The low oral toxicity of DOWFROST fluid and the moderate oral toxicity of DOWTHERM SR-1 fluid. The virtual absence of fluid odor or taste. Low corrosivity. Easy fluid analysis and reinhibition. Fast freezing performance. Dependable temperature control. Low flammability. No auto-ignition hazard. Easy regeneration and reconcentration. And, easy system maintenance and operation. These advantages can translate into significant productivity gains and cost savings as the following applications illustrate.

Chilling/Freezing

Cooling Liquid Foods

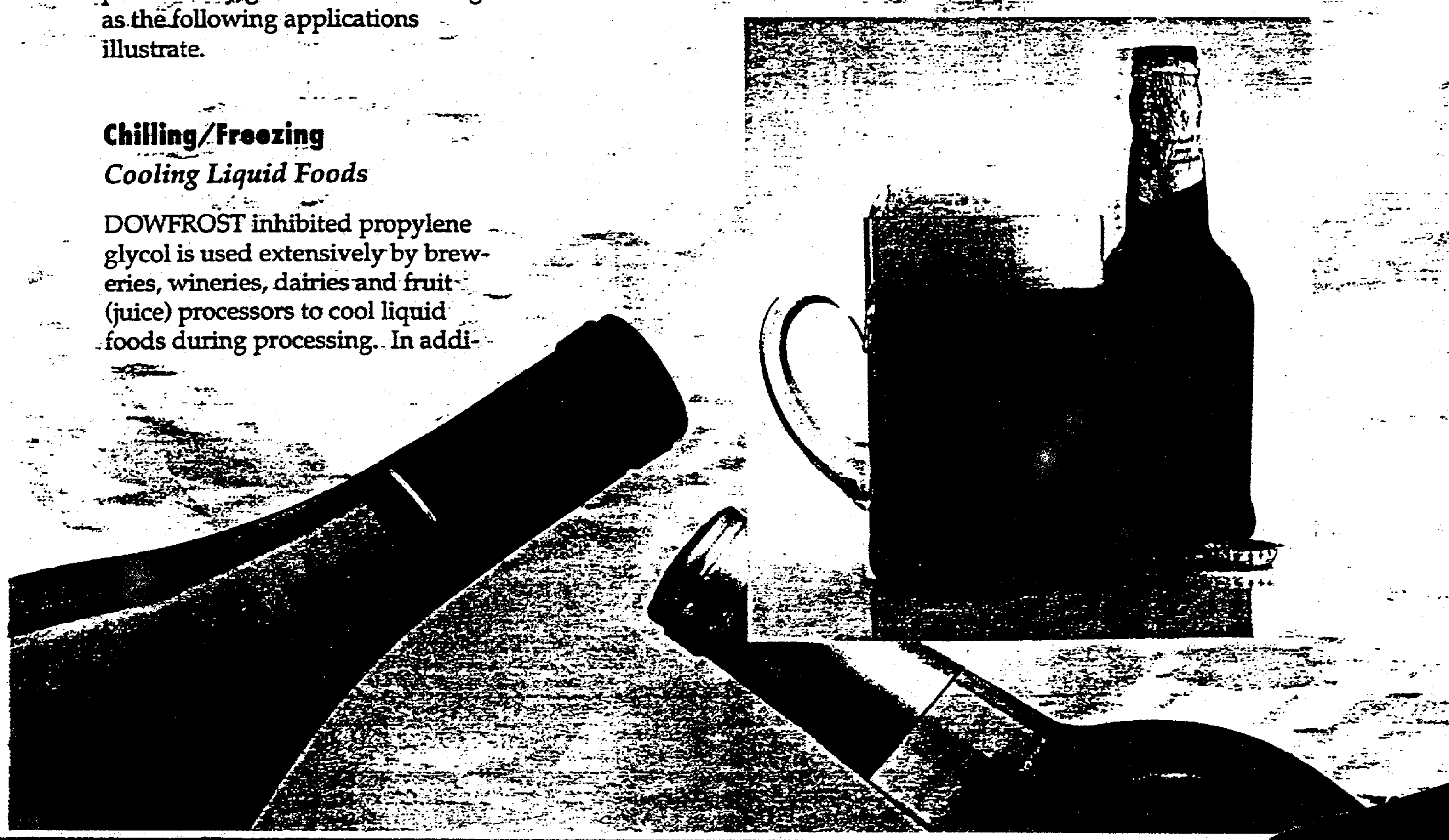
DOWFROST inhibited propylene glycol is used extensively by breweries, wineries, dairies and fruit (juice) processors to cool liquid foods during processing. In addition, it is used by restaurants and bars, as well as in vending machines, to cool liquid beverages as they are dispensed.

In beverage processing, a 30 to 45 percent solution of DOWFROST fluid is circulated through cooling coils which may be submerged within a tank, or wrapped around it. The fluid provides dependable temperature control and lower temperature capabilities than water, so liquids can be chilled to 33°F or lower. In dairy operations, production is increased because milk products can be bottled faster. DOWFROST fluid is nonflammable in solution.

Fermentation Cooling

DOWFROST fluid is also used by breweries and wineries to cool fermentation and wort tanks, and for refrigeration of yeast bulk storage tanks. A 30 to 45 percent solution of DOWFROST fluid is chilled in a primary refrigeration unit. The chilled fluid is then circulated through coils submerged in—or wrapped around—the tank.

DOWFROST fluid is low in toxicity and odor, and is virtually tasteless—important benefits since accidental contact with beverage products can occur in cooling operations. DOWFROST fluid will not affect the foaming or fermenting properties of beer or wine. And, the low temperature capability of DOWFROST fluid permits recovery of CO_2 generated during fermentation. This CO_2 can then be used later in the bottling process.



Packaging Carbonated Beverages

Sparkling wines, champagne, beer and other carbonated beverages are chilled prior to bottling to prevent loss of carbonation. For some beverages, cold DOWFROST fluid is pumped through coils submerged in —or wrapped around—a process tank. In champagne production, inverted bottles of aged champagne are dipped in a chilled bath of DOWFROST fluid, freezing the contents in the neck of the bottle. This traps sediment for removal. Consistent product chilling is achieved because system equipment is easy to operate and fluids are easy to maintain and adjust.

Immersion Freezing of Wrapped Foods

Considered chemically acceptable by the USDA and complying with FDA food additive regulations, DOWFROST fluid is commonly used for immersion freezing by processors of wrapped meat, poultry, fish, seafood, vegetables, and fruit. Immersion freezing owes its popularity among food processors to its speed and efficiency. Plus, it provides uniform freezing, a particular challenge with irregularly shaped foods. DOWFROST fluid provides faster freezing of foods than air or plate freezing, so production rates are increased. The speed with which products are cooled also reduces surface bacteria counts. And frozen product appearance and shelf life are improved.

In a typical immersion freezing process, food is tightly wrapped and sealed in air- and water-tight bags. It is then immersed in a freezing bath (12°F) of 40 to 50 percent DOWFROST fluid in solution with water. In some cases, the wrapped foods are carried on a conveyor through freezing equipment where they are sprayed with a solution of cold DOWFROST fluid. Food is bathed or sprayed until the proper depth of freeze is achieved, usually 3/8" to 1/2". Then the food packages are rinsed with water to remove excess glycol and are transported to a freezing room.

Plastic Bottle Blow Molding

DOWFROST fluid is widely used by large dairies, other food processors and packaging companies to cool molds used to blow mold plastic bottles. A 30 to 45 percent solution of DOWFROST fluid is circulated through the mold for rapid cooling. Because these fluids remain liquid at lower temperatures than plain water, they cool molds faster, increasing production. Faster cooling also allows "flash" to be trimmed more quickly and cleanly, improving product quality.

Ice Making

Ice production plants use DOWFROST fluid to freeze water quickly. Steel trays of water are lowered into tanks filled with a refrigerated and agitated 40 to 50 percent solution of DOWFROST fluid.

Defrosting/Dehumidifying

Refrigeration Coil Defrosting

In walk-in freezer and chiller units, freezing tunnels, and basket freezer units, moisture from the air can condense on refrigeration coils and a layer of frost can develop. As this frost builds up, compressor motors work harder to maintain proper temperatures and cooling efficiency suffers. To remove condensation from coils and prevent frost formation, cold 35 to 50 percent solutions of DOWFROST fluid, or 40 to 50 percent solutions of DOWTHERM SR-1 fluid, are sprayed directly on the coil surfaces. This spraying may be continuous or, "as needed." The glycols mix with condensation from the coils, lowering the freeze point of the water to prevent frost formation.

Because they contain special corrosion inhibitors, DOWFROST and DOWTHERM SR-1 fluids minimize coil corrosion. They are also easy to regenerate and reconcentrate, and production need not be interrupted for defrosting procedures to take place. Defrosting systems using DOWFROST and DOWTHERM SR-1 fluids are easy to operate and maintain.

Humidity Control

To maintain a constant relative humidity in work and storage areas, meat packers, producers of sausage and processed meats, and slaughterhouses spray DOWFROST or DOWTHERM SR-1 fluid through the air that flows over plant refrigeration coils. The sprayed glycol picks up moisture from the air, and filters dust and other particles. High humidity supports growth of mold and bacteria that cannot be tolerated in these operations. Since DOWFROST and DOWTHERM SR-1 fluids are easily reconcentrated, they are very economical in humidity control applications.

DOWFROST and DOWTHERM SR-1

Two distinct inhibited glycol formulations to meet your specific heat transfer needs

DOWFROST inhibited propylene glycol

DOWFROST fluid has an effective temperature range of -28°F to 250°F for continuous use. Below -28°F, the increased viscosity of the fluid makes it impractical for use without special equipment. However, the fluid can be used to protect enclosed heat transfer systems from freeze damage at well below -60°F. Heat transfer is generally efficient to 0°F. See the back of this brochure for physical properties data for DOWFROST fluid.

DOWFROST fluid is not recommended for use as a direct food additive. However, its low toxicity and virtual absence of odor and taste make it suitable for use in food processing operations where accidental contact with food products could occur. As with any fluid used in food processing, good manufacturing practices are required.

Regulatory status

U.S. Department of Agriculture (USDA)

DOWFROST heat transfer fluid is listed as chemically acceptable by the USDA for both defrosting refrigeration coils and for immersion freezing of wrapped meats, poultry, and meat products in plants operated under federal inspection.

Food and Drug Administration (FDA)

The FDA clears only individual chemicals, not proprietary products (trademarks). The two ingredients in DOWFROST fluid are generally recognized as safe by the FDA as food additives under Parts 182 and 184 of the Food Additive Regulations. The regulation for propylene glycol is 21 CFR 184.1666; for dipotassium phosphate, 182.6285. The propylene glycol and dipotassium phosphate in DOWFROST fluid meet the requirements of these regulations.

Grade A dairies and meat packing establishments sometimes require a letter certifying the appropriate use and quality of DOWFROST fluid. Such a letter, along with copies of the acceptance letters from the USDA and a statement of FDA compliance, will be provided to any Dow customer on request.

DOWTHERM SR-1 inhibited ethylene glycol

DOWTHERM SR-1 fluid has an effective use temperature range of -60°F to 250°F. Its lower minimum temperature makes DOWTHERM SR-1 fluid the preferred medium in the food industry for continuous defrosting of coils in large refrigeration and freezer units where temperatures are too low to use propylene glycol fluids. Because of its moderate oral toxicity, DOWTHERM SR-1 fluid is not used where direct contact with food products is possible.

Below -60°F, the increased viscosity of DOWTHERM SR-1 fluid makes it impractical for use without special equipment. However, the fluid can be used to protect enclosed heat transfer systems from freeze damage at temperatures below -100°F. Heat transfer is generally efficient to -10°F. See the back of this brochure for physical properties data for DOWTHERM SR-1 fluid.

Regulatory status

U.S. Department of Agriculture (USDA)

DOWTHERM SR-1 fluid is listed as chemically acceptable by the USDA for defrosting refrigeration coils in plants operated under federal inspection, assuming good manufacturing practices to prevent direct or indirect contact of the glycol fluid with edible products.

Meat packing establishments sometimes require a letter certifying the appropriate use and quality of DOWTHERM SR-1 fluid. Such a letter, along with copies of the acceptance letter from the USDA, will be provided to Dow customers on request.

How Dow inhibitors prevent corrosion that plain glycols can encourage

DOWFROST inhibited propylene glycol and DOWTHERM SR-1 inhibited ethylene glycol provide corrosion protection that can extend system and equipment life—and reduce costly downtime—without compromising heat transfer performance.

Uninhibited glycols oxidize in the presence of air at elevated temperatures, forming organic acids. These acids can lower the pH of the glycol solution, creating an environment for corrosion.

But the inhibitors in DOWFROST and DOWTHERM SR-1 fluids maintain a stable pH by reacting with any organic acids that may be formed. They provide substantial corrosion protection for steel, cast iron, copper, aluminum, brass, and solder as demonstrated by ASTM D1384 corrosion testing.†

Table 1 shows the corrosion rates of common metals exposed to DOWFROST and DOWTHERM SR-1 fluids, as well as two uninhibited glycol solutions and plain water. The presence of excessive amounts (>50 ppm) of contaminants such as chloride, sulfate or ammonia could contribute to corrosion not evident in the tests used to prepare this data.

†DOWFROST and DOWTHERM SR-1 fluids are not recommended for use with galvanized steel. The zinc in the galvanized coating could react with inhibitor components, thus precipitating out of the fluid and causing fouling as well as inhibitor depletion.

Table 1: Comparative Corrosion Effects of Fluids on Common Metals

	Corrosion Rates (mils per year)				
			DOWFROST		DOWTHERM SR-1
Metal	Plain Water	Uninhibited Propylene Glycol	Inhibited Propylene Glycol	Uninhibited Ethylene Glycol	Inhibited Ethylene Glycol
Copper	0.08 mpy	0.16 mpy	0.20 mpy	0.16 mpy	0.12 mpy
Solder	3.14	34.7	0.03	56.5	0.14
Brass	0.22	0.20	0.16	0.46	0.11
Steel	9.69	9.8	0.04	44.5	0.03
Cast Iron	21.2	16.2	0.15	55.7	0.13
Aluminum	13.2	1.8	0.26	19.8	0.44

NOTE: The test data information is recommended for screening purposes only. Rates in excess of 0.5 mpy (2.5 mpy for aluminum) are generally not considered adequate for corrosion protection.

†Based on corrosion test ASTM D1384; 190°F – 2 weeks; standard ASTM test metals 30% glycol in deionized water; air bubbling.

Drawbacks of unbranded inhibited glycols

Unbranded or "generic" inhibited glycols can present problems in food industry applications. First, the degree of corrosion protection these fluids provide is often a mystery. Unless the manufacturer or supplier can demonstrate a successful history of use in the food industry, there may be no way of knowing what kind of protection the fluid will provide, and for how long. Furthermore, once the fluid is in use, ongoing inhibitor condition can be difficult to analyze. That means that the fluid could require frequent (and costly) replacement to assure that corrosion protection is maintained.

In contrast, the specially blended inhibitors in DOWFROST and DOWTHERM SR-1 fluids have been proven effective as corrosion deterrents in years of food industry use. And, to assure ongoing corrosion protection, DOWFROST and DOWTHERM SR-1 fluids are easily analyzed to determine corrosion inhibitor condition. If the inhibitors are depleted, Dow can supply additional inhibitors—so the fluid is economically reinhibited rather than replaced.

Dow provides complete fluid support services including free analysis

DOWFROST and DOWTHERM SR-1 fluids are backed by comprehensive Dow supporting services. With extensive experience in supplying heat transfer fluids to the food industry, Dow technical service personnel can help you design, operate and maintain your thermal fluids system for maximum productivity and economy.

For systems containing 250 gallons of fluid or more, Dow offers free fluid analysis. Typically performed on an annual basis, the analysis includes determination of current fluid inhibitor and glycol levels, plus Dow's recommendations for maintaining proper corrosion protection and thermal performance capabilities. Dow also provides assistance to operators of smaller systems so that they can conduct their own on-site fluid analyses.

Call 1-800-258-2436

Call toll free for more information about DOWFROST and DOWTHERM SR-1 fluids, or to receive specific technical assistance. Just ask for Extension DOWFROST.

DOWFROST and DOWTHERM SR-1

Inhibited glycol heat transfer fluids for food industry applications

Table 2. Typical Physical Properties†† of DOWFROST and DOWTHERM SR-1 Fluids

		DOWFROST Inhibited Propylene Glycol	DOWTHERM SR-1 Inhibited Ethylene Glycol
Useful Operating Temperature		-28°F to +250°F	-60°F to +250°F
Freeze Point, °F	30%	+8°F	+4°F
	50%	-28°F	-34°F
Viscosity, Centipoise			
	50% at -20°F	150	46
	0°F	68	22
	50°F	10	6
	200°F	0.9	0.9
Thermal Conductivity			
Btu/(hr.) (ft.^{2}) (°F/ft.)	50% at 0°F	0.23	0.206
	100°F	0.225	0.228
Specific Heat			
Btu/(lb) (°F)	50% at 40°F	0.83	0.81
Specific Gravity	25/25°C	1.045 –1.055	1.125 –1.135
Flash Point			
Concentrate			
Pensky-Martens Closed Cup (PMCC)		214°F	250°F
Cleveland Open Cup (COC)		220°F	250°F
Aqueous Solutions up to 80% Glycol			
Tag Closed Cup		No Flash Point	No Flash Point

††Typical properties, not to be construed as specifications.

Call 1-800-258-2436

for the name of your nearest distributor for DOWFROST and DOWTHERM SR-1 fluids. Ask for Extension: DOWFROST.

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DOWFROST HD

HEAT TRANSFER FLUID

Engineering Specifications for Closed-Loop HVAC Systems

MANUFACTURER
The Dow Chemical Company
Thermal Fluids Business
100 Larkin Center
Midland, Michigan 48674
Phone: 1-800-447-4369

GENERAL PRODUCT DESCRIPTION

DOWFROST* HD industrially inhibited propylene glycol-based heat transfer fluid is manufactured by The Dow Chemical Company. Aqueous solutions of DOWFROST HD fluid are designed to provide freeze/burst and corrosion protection, as well as efficient heat transfer, in water-based, closed-loop heating and air-conditioning systems.

DOWFROST HD fluid has an operating temperature range of -50°F to 325°F; with fluid freeze protection to below -60°F, and system burst protection to below -100°F. The fluid contains corrosion inhibitors that are specially formulated for HVAC systems to keep pipes free of corrosion without fouling. DOWFROST HD fluid can be specified for use in new HVAC systems, or as a replacement fluid for use in existing systems. The fluid is dyed bright yellow to facilitate system leak detection.

DOWFROST HD fluid is also suitable for ice storage systems — used either in the closed circulation loop from the chiller to the storage medium; or, in solution with water, in the medium itself.

Compared to DOWFROST fluid, DOWFROST HD fluid features a higher maximum operating temperature, higher reserve alkalinity and greater thermal stability for longer fluid life. Extra-strength corrosion inhibitors in DOWFROST HD fluid are formulated for high temperature use, resulting in reduced maintenance and longer inhibitor life in most applications.

DOWFROST fluid is recommended for use in applications where low acute oral toxicity is important or where incidental contact with drinking water is possible.

Since the toxicity of heat transfer fluids may be adversely altered in HVAC systems, used fluids should be handled with reasonable care, and not be taken internally.

HVAC SYSTEM FLUID SPECIFICATION

Closed-loop, water-based systems

1. FLUID MATERIAL

The propylene glycol to be used in such a system must meet the following requirements:

1.1 The fluid must be an industrially inhibited propylene glycol (phosphate-based).

1.2 The fluid must be dyed [bright yellow] to facilitate leak detection.

1.3 The fluid must be easily analyzed for glycol concentration and inhibitor level.

1.4 For systems containing more than 250 gallons of fluid, annual analysis must be provided free of charge by the fluid manufacturer.

1.5 The fluid must pass ASTM D1384 (less than 0.5 mils penetration per year for all system metals).

1.6 The reserve alkalinity of the fluid must be at least 15 to provide long-term resistance to acidic pH.

2. FLUID INSTALLATION

Follow these installation procedures:

2.1 Clean new or lightly corroded existing systems with a 1% to 2% solution of trisodium phosphate in water prior to the installation of industrially inhibited propylene glycol fluid.

2.2 Extensively corroded existing systems should be cleaned by an industrial cleaning company and all necessary replacements and repairs should be made.

2.3 **Use only good quality water in solution with the propylene glycol fluid. Use water with low levels (less than 25 ppm) of chloride and sulfate, and less than 50 ppm of hard water ions (Ca^{++}, Mg^{++}). Distilled or deionized water is recommended.** If good quality water is unavailable, purchase pre-diluted solutions of industrially inhibited propylene glycol fluid from the fluid manufacturer or, if available, from the distributor.

3. SYSTEM DESIGN CONSIDERATIONS

3.1 Avoid use of automatic water make-up systems to prevent undetected dilution of the propylene glycol and possible contamination of the water system.

4. TECHNICAL DATA

4.1 DOWFROST HD Fluid, Product Description

Composition, % by weight

Glycols	94
Inhibitors and water	6
Color	Bright Yellow
Specific gravity at 60/60°F	1.053 - 1.063
pH of solution containing 50% glycol	9.5 - 10.5
Reserve alkalinity, minimum	15.0 ml

4.2 Typical Properties of Aqueous Solutions†

(Glycol percentage by volume)

Physical Property	Temp. °F	30% Glycol Solution	40% Glycol Solution	50% Glycol Solution	60% Glycol Solution
Thermal	40	0.247	0.225	0.204	0.184
Conductivity	180	0.279	0.249	0.221	0.195
Btu/(hr•ft²)(°F/ft)	325	0.268	0.238	0.210	0.184
Specific Heat,	40	0.894	0.847	0.794	0.734
Btu/(lb•°F)	180	0.947	0.916	0.878	0.833
	325	1.002	0.987	0.965	0.936
Viscosity,	40	5.75	9.63	14.28	23.65
Centipoise	180	0.68	0.85	1.08	1.29
	325	0.31	0.39	0.40	0.45
Density,	40	65.30	66.03	66.68	67.23
(lb/ft³)	180	62.60	63.09	63.50	63.83
	325	57.89	58.18	58.41	58.59

†Typical properties, not to be construed as specifications.

4.3 Freezing and Boiling Points of Aqueous Solutions

Freezing Temperature, °F	% Glycol by Volume	Boiling Temperature, °F
26	10	212
19	20	213
8	30	216
-7	40	219
-28	50	222
-60	60	225
<-60	70	230

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