



HITEC[®] Heat Transfer Salt

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NOTICE: HITEC® IS A STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. IT CAN CAUSE IRRITATION. See Personal Safety and First Aid on page 8.

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INTRODUCTION

With the increased use of high-temperature operations, the chemical and petroleum process industries need an economical, efficient, heat transfer medium that is between steam and direct-fire heating. To help meet this need, the Coastal Chemical Company offers HITEC* heat transfer salt (formerly HTS).

Freshly prepared HITEC is a white, granular solid; when melted, pale yellow. HITEC is an eutectic mixture of water-soluble, inorganic salts of potassium nitrate, sodium nitrite and sodium nitrate. It is a heat transfer medium for heating and cooling between 300-1100°F (149-538°C) that is used in process operations, such as reactor temperature maintenance, high-temperature distillation, reactant preheating, rubber curing, and rotational molding.

Spinnerettes, spinning heads, strainers, extruder screws and other polymer handling equipment may be cleaned of polymers by immersion in a molten oxidizing eutectic salt mixture such as HITEC. This procedure has the obvious advantage of oxidizing the polymer from precision surfaces at relatively low temperatures with negligible corrosion, pitting or dimension change.

HITEC is used because it has a low melting point (288°F, 142°C), high heat transfer coefficient, thermal stability, and low cost. It is nonfouling – a commonly recognized defect of many organic heat transfer media. HITEC is nonflammable, nonexplosive and evolves no toxic vapors under recommended conditions of use.

HITEC keeps investment and operating costs to a minimum. It can be used at atmospheric pressure which eliminates the necessity for expensive, high-pressure equipment. It has a low degree of corrosivity toward common materials of construction. Plain carbon steel, for example, can be used for installations that operate up to 850°F (454°C).

Because of the high heat transfer coefficients and high heat capacity of HITEC, equipment size and surface areas for heat transfer can be held to a minimum. Maintenance and power costs for circulating the salt are correspondingly low.

PROPERTIES

FREEZING POINT

The freezing point of fresh HITEC heat transfer salt is 288°F (142°C). Therefore it can be melted readily by plant steam at a pressure as low as 50 psig. A small amount of moisture sharply reduces the freezing point. Therefore, to determine it accurately, the salt should be melted and dried at about 480°F (249°C). This may cause effervescence or frothing, depending on the amount of moisture. Suitable precautions should be taken to protect personnel from spattering by the hot, molten salt.

VISCOSITY

The viscosity of molten HITEC was measured at 300-820°F (149-438°C); these data were extrapolated to 1000°F (538°C) as shown in Figure 1.

ELECTRICAL RESISTIVITY

The electrical resistivity of molten HITEC is 1.7 Ω•cm, which is approximately midway between water (25 x 10⁶ Ω•cm) and mercury (95.9 x 10⁻⁶ Ω•cm).

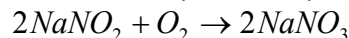
THERMAL STABILITY

HITEC heat transfer salt is very stable; without contaminants the salt mixture gives many years of excellent service at temperatures up to about 850°F (454°C). Between 850° and 1000°F (454 and 538°C) [the maximum recommended operating temperature for HITEC] the salt, when used in a closed system, undergoes a slow thermal breakdown of the nitrite to nitrate, alkali metal oxide, and nitrogen:



Nitrogen gas evolves slowly and the freezing point of the salt mixture gradually rises. Above 1500°F (816°C) nitrogen evolves so rapidly that the molten salt appears to boil. Decomposition ceases as soon as the source of heat is removed, which indicates the decomposition reaction is endothermic.

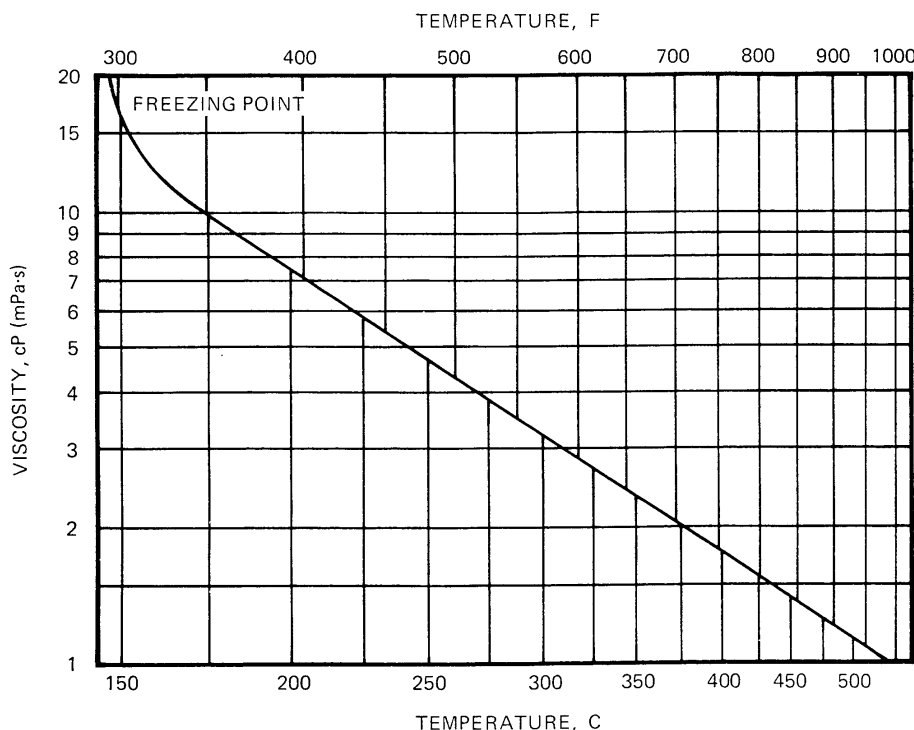
When HITEC is used in an open system, in contact with the air, and in the higher operating range between 350 and 1000°F (454-538°C), the nitrite is slowly oxidized by atmospheric oxygen:



Other lesser reactions under these conditions which gradually alter the composition of the salt mixture are (1) the absorption of carbon dioxide to form carbonates which may precipitate and (2) the absorption of water vapor to form alkali metal hydroxides. These reactions which tend to raise the freezing point can be eliminated by blanketing the molten salt with nitrogen

*Reg. U.S. Pat. & Tm. Off., Coastal Chemical Company

FIGURE 1
VISCOSITY OF LIQUID HITEC®



DENSITY

In Figure 2, by drawing a straight line from the temperature through the reference point, density can be read in g/ml (Mg/m³), lb/ft³, or lb/U.S. gal.

THERMAL CONDUCTIVITY

Thermal conductivity measurements (Figure 4) on HITEC* heat transfer salt have been reported.^a A value of 0.35 Btu•ft/ft²•h•F independent of temperature at 468-689°F 242-365°C) was obtained using a parallel-plate, variable sample gap apparatus.^b Battelle Memorial Institute, in a similar apparatus, extended the temperature range and obtained a value of 0.33 Btu•ft/ft²•h•F independent of temperature at 400-900°F (204-482°C).^c

An earlier Russian article^d reported values at 302-932°F (150-500°C) that ranged from 0.26 to 0.17 Btu•ft/ft²•h•F.

HEAT TRANSFER COEFFICIENT

Heat transfer coefficients (h) for HITEC (that flows in turbulent motion inside horizontal, circular, iron pipes) have been determined at 580-960°F (304-516°C) at linear velocities up to 6 ft/sec.^e Data on the thermal conductivity of HITEC were lacking; therefore, the experimental results were correlated with

$\frac{hD}{\mu^{0.4}}$. Since this work was published, additional determinations of the coefficient were reported^f which apparently utilized a more accurate apparatus than that used

earlier. The data were correlated using the Colburn j function,

$$\left(\frac{h}{C_p G}\right) \left(\frac{C_p \mu}{k}\right)^{2/3}$$

The variables were reported to range:

Reynolds modulus (N _{Re}), $\frac{DG}{\mu}$	4850-24,710
Prandtl modulus (N _{Pr}), $\frac{(C_p \mu)}{k}$	4.2-9.1
Average fluid temperature, F	552-828
C	289-442
Heat Flux	62,800-194,500 Btu/hr•ft ²

Under these conditions, the heat transfer coefficient varied from 800-2900 Btu/hr•ft²•F. In heat transfer applications, HITEC behaves as a normal fluid and the standard correlations may be used in designing heat exchange equipment.

THERMAL EXPANSION

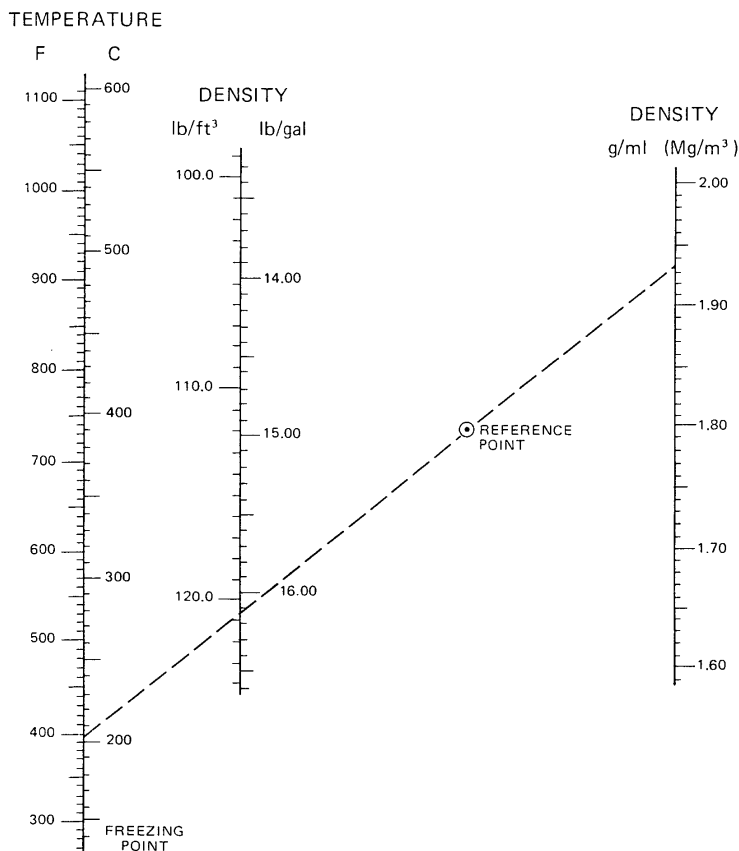
The coefficient of linear thermal expansion for solid HITEC is 2.85 x 10⁻⁵/F (5.13 x 10⁻⁵/C)^g. The coefficient of cubical thermal expansion for liquid HITEC is 2.016 x 10⁻⁴/F (3.629 x 10⁻⁴/C)^h.

SPECIFIC AND LATENT HEAT

The total heat of HITEC was measured calorimetrically at 70-1100°F (21-593°C). The slopes of the total heat-temperature lines (Figure 3) indicate the specific heat of solid HITEC is 0.32 cal/g•C (Btu/lb•F) and the melt, 0.373. Latent heat of fusion is about 20 cal/g (35 Btu/lb).

*Reg. U.S. Pat. & Tm. Off., Coastal Chemical Co.

FIGURE 2
DENSITY OF LIQUID HITEC®



NOTE: TO FIND DENSITY, DRAW A STRAIGHT LINE FROM DESIRED POINT ON TEMPERATURE SCALE THROUGH THE REFERENCE POINT.

TABLE I
COMPARISON OF HITEC* AND AIR AS HEAT TRANSFER FLUIDS

	HITEC		AIR
		3 atm. press.	10 atm. press.
Pressure drop/100 ft	3.5 lb/in ²	3.5 lb/in ²	3.5 lb/in ²
Flow Rate for each tube	6000 lb/hr	185 lb/hr	360 lb/hr
Heat Carrying Capacity/tube	111,900 Btu/hr	2310 Btu/hr	4500 Btu/hr
No. of 1" tubes required to transfer 111,900 Btu/hr at 50°F (28°C) temperature difference	1	48.5	25
Total lb/hr	6000	8970	8970
Theoretical HP required to overcome friction	0.014	24.1	7.2
Individual coefficient of heat transfer	858	28	40
Basis of comparison:			
<ul style="list-style-type: none"> • fluid conduit: 1" I.D. tubes • average fluid temperature: 800°F (427°C) • pressure drop due to friction: 3.5 lb/in² for each 100 ft. of tubing • difference between inlet and outlet fluid temperatures: 50°F (28°C) 			

*Reg. U.S. Patent. & Tm. Off., Coastal Chemical Company

FIGURE 3

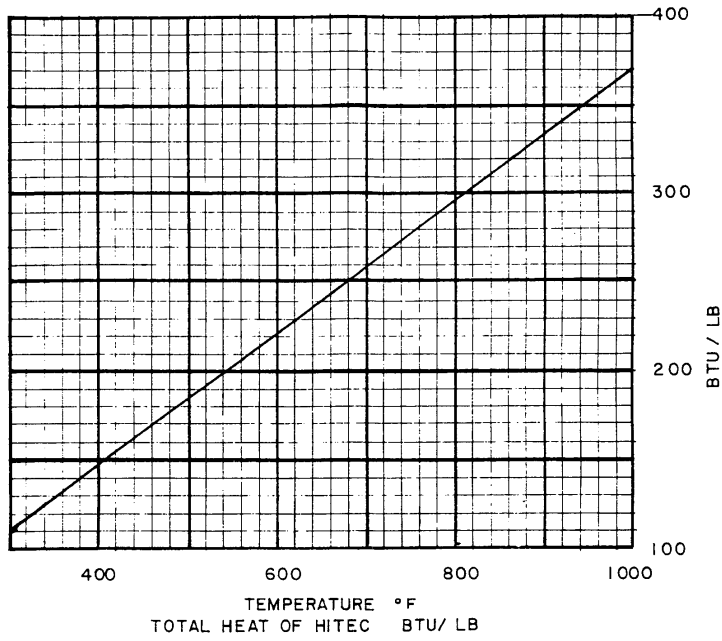
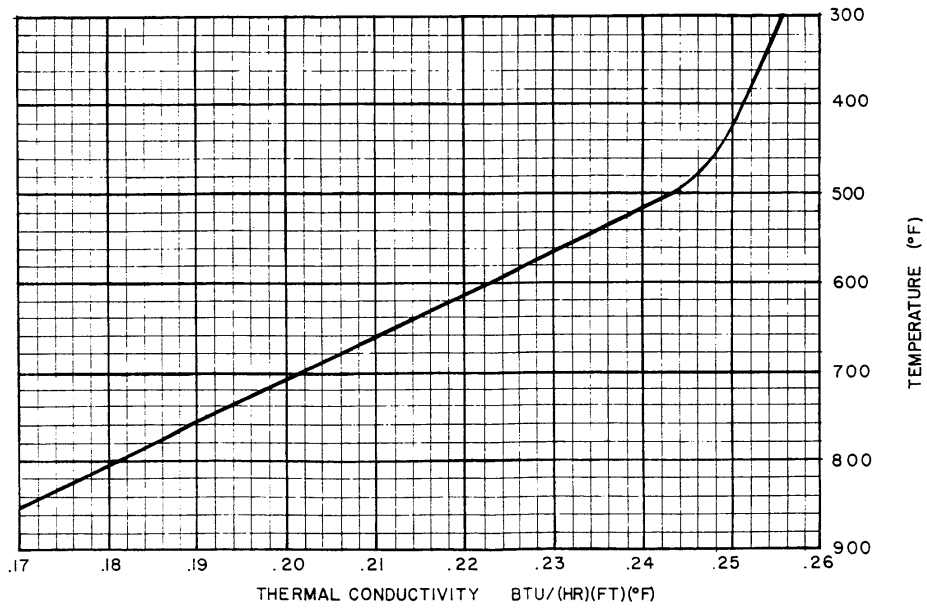


FIGURE 4



EFFICIENCY

The efficiency of HITEC* heat transfer salt can be directly compared to hot air or flue gas on a performance basis (Table I).

Exposure, hr	Corrosion rate, in. penetration/mo.
46	0.00076
92	0.00054
163	0.00040
236	0.00030

MATERIALS OF CONSTRUCTION

Equipment of plain carbon steel is used satisfactorily with HITEC to 850°F (454°C). More resistant alloys are recommended for higher operating temperatures (Table II).

The data at 1058°F (570°C) in Table II indicate that corrosion of stainless steel decreases during exposure. This effect was further examined for Carpenter 20 test pieces by cleaning, weighing, and measuring the pieces before exposing at 1058°F (570°C) for an additional period:

Copper equipment has been used satisfactorily with HITEC at moderate temperatures. In a copper reaction vessel heated with HITEC which had been in operation for 2 years at 600°F (316°C), the only change observed was complete annealing of the metal.

A black film formed on a test coupon of cast iron on exposure to HITEC at 600-800°F (316-427°C), and the attendant gain in weight was indicative of a reaction between HITEC and the carbon in the iron. Therefore, the use of cast iron equipment with HITEC is not recommended because of the possibility of embrittlement of the metal and/or fissuring.

**TABLE II
CORROSION OF METALS BY HITEC**

Metals	Corrosion Rate, Inches Penetration Per Month						
	612°F 322°C	785°F 418°C	850°F 454°C	1000°F 538°C	1058°F 570°C	1100°F 593°C	
					1 st Period	2 nd Period	
Steel – open hearth (ASTM A273, A274)	-	-	0.0003	0.01 to 0.002	-	-	0.01 to 0.05
Alloy steel – 15-16% chromium iron	-	-	-	0.0000	-	-	-
Stainless Steels							
Type 304	-	-	-	0.0007	-	-	-
Type 304L	-	-	-	0.006	-	-	-
Type 309 (annealed)	0.00002	0.00001	0.0000	-	0.00110	0.00064	-
Type 309 Cb	-	-	-	-	0.00156	0.00094	-
Type 310	-	-	-	-	0.00117	0.00077	-
Type 316	-	-	-	0.0000	-	-	-
Type 321	-	-	-	-	0.00111	0.00056	-
Type 347	-	-	-	0.0004	0.00109	0.00068	-
Type 446	-	-	-	-	0.00146	0.00072	-
Inconel ¹	-	-	-	0.0000	0.00153	0.00151	-
Carpenter 20	-	-	-	-	0.00097	0.00059	-
Hastelloy ² B	0.00011	0.000003	-	-	-	-	-
Monel ¹	-	-	-	0.0001	-	-	-
Bronze	0.00006	0.00008	0.0001	-	-	-	-
Phosphorized Admiralty	0.00006	0.00005	0.0001	-	-	-	-
Copper	-	-	-	0.03	-	-	-
Nickel	-	-	-	-	-	-	0.0025

¹ Reg. U.S. Pat. & Tm. Off., Huntington Alloy Products Division, The International Nickel Co., Inc.

² Reg. U.S. Pat. & Tm. Off., Cabot Corporation

*Reg. U.S. Pat. & Tm. Off., Coastal Chemical Company

Stainless-steel equipment, however, may be used at temperatures over 1000°F (538°C). Seamless, stainless tubing had no visible corrosive attack after almost continuous exposure to circulating HITEC* for 10 months at 930-1020°F (499-549°C).

EQUIPMENT DESIGN

Flat-faced flanged fittings are generally satisfactory for piping to carry HITEC, but tongue-and-groove type fittings are recommended for severe applications. Welded pipe bends and connections should be used whenever possible. Piping should be laid out so that the molten salt will drain by gravity to the storage reservoir when the unit is shut down. Exposed salt lines and valves should be insulated to prevent excessive radiation of heat, although for some high temperature applications, it is necessary to use valves fitted with radiation fins to protect the packing glands. Salt lines and valves should be traced or steam jacketed to prevent freezing by solidified salt, especially for intermittent operations.

Manually operated, steel gate valves and automatic valves can be used that are installed so that they can drain freely. Submerged centrifugal pumps that permit no contact of the liquid with the packing gland can be used to circulate molten HITEC.

Metallic asbestos gaskets, asbestos sheet gaskets, and asbestos packing have all been used successfully. Organic valve-packing lubricants or excessive pipe dope should be avoided to prevent a reaction between the organic material and HITEC. Graphite lubricated asbestos is satisfactory with minimal graphite content.

The salt-heating unit should be designed to prevent localized overheating during startup and when the circulation of salt might be stopped suddenly. HITEC is preferably remelted with electric immersion heaters or steam coils that pass through the surface of the salt. Heating a "frozen" bath of HITEC from the bottom alone can develop sufficient pressure to rupture equipment or, more likely, to expel molten HITEC through the solid salt surface.

PRECAUTIONS IN USE

The principal hazards associated with HITEC heat transfer salt apply to any operation that involves elevated temperature liquids. Adequate precautions should be taken to protect operating personnel from burns in case of equipment failure. There is some danger that HITEC, by supporting the combustion of other materials, may escalate an existing fire hazard.

COMBUSTION HAZARD

Although HITEC is nonflammable; it is a strong oxidizer and supports the combustion of other materials. Salt units using HITEC should not be located near wooden construction. Contamination of the work area with HITEC may increase any fire hazard created by combustible materials. These problems may be minimized by washing the work area regularly with water and substituting noncombustible materials for combustible

materials. For example, sand rather than sawdust should be used for clean-up, diking, etc. The user should test any novel applications of hot, molten HITEC. Combustible vapors generally react relatively slowly with HITEC and escape before combustion is complete. Gasoline vapors, high in saturated compounds, were bubbled through the molten salt for 2 hours at 1100°F (593°C); over 90% of the gasoline was recovered unchanged. HITEC and ammonia was also studied under similar conditions, less than 50% of the ammonia reacted over 2 hours at 1100°F (593°C). In both cases, changes in the salt were minor.

Flammable liquids vaporize rapidly in contact with molten HITEC and burn as they might on any hot surface. Crude oil, for example, burned similarly on the surface of HITEC at 1150°F (621°C) and on the surface of molten lead at the same temperature. Motor gasoline, cracked gasoline, gas oil, and crude oil mixed with sulfur were released below the surface of an open container of HITEC at 100°F (593°C). The hydrocarbons vaporized and burned; hot salt splattered considerably from the rapid sub-surface vaporization of the crude oil and gasoline. The salt composition changed little, indicating that the principal reactions were between the vaporized hydrocarbons and the air above the salt bath.

Combustible solids, such as wood, coke, paper, plastics, cyanides, chlorates, ammonium salts, and active metals, such as aluminum and magnesium, offer somewhat greater hazards. Magnesium, (except as an alloying agent in low concentration) must not come in contact with HITEC. Heat treatment of aluminum parts in molten HITEC is a common and safe practice when suitable precautions are taken as in "Potential Hazards in Molten Salt Baths for Heat Treatment of Metals."ⁱ

It is possible for solid combustible materials to remain in contact with the hot salt until they are completely oxidized, large volumes of combustion gases can be formed rapidly beneath the salt surface. This could result in violent spattering of hot salt or rupture of equipment.

When ground petroleum coke is held beneath the surface of HITEC at 1150°F (621°C), and contacts iron, a very high temperature reaction occurs. Similarly, mixtures of fine aluminum and iron filings react with HITEC at 1000°F (538°C); enough heat evolves to burn through a nickel crucible.

Finely divided charcoal flares up and burns vigorously when placed on the surface of HITEC at 1200°F (649°C), but grease burns quietly under the same conditions. When an oxygen-balanced mixture of HITEC and paraffin are heated rapidly to 1100°F (593°C), the paraffin merely volatilizes and burns, leaving the salt practically unchanged. However, an 80/20 mixture of HITEC and nylon burns vigorously at 750°F (399°C); analysis indicates the oxidizing salts take part in this reaction as they did with coke beneath the surface.

All attempts to detonate HITEC or mixtures of HITEC with combustible products, such as paraffin, petroleum and nylon, at 375°F (190°C) and 25 in. of mercury vacuum were unsuccessful with either a No. 8 blasting cap or 0.5 lb. of blasting gelatin as the initiator. The salt was similarly insensitive at 1100°F

*Reg. U.S. Pat. & Tm. Off., Coastal Chemical Company

(593°C). Attempts to detonate an oxygen-balanced mixture of HITEC* and finely divided charcoal by heating the mixture vigorously under confinement were also unsuccessful. It is estimated that pressures as high as 18,000 psi were attained during this test.

HITEC itself liberates no toxic vapors, but adequate ventilation should be provided to remove any combustion products that might result from purposeful or accidental contamination of a HITEC bath. Water from spray sprinklers or low-velocity fog nozzles will not penetrate the surface of molten HITEC sufficiently to cause dangerous spattering. They are recommended for oil-fired units and for processes involving combustible materials. Carbon dioxide and approved dry-powder type fire extinguishers can be used satisfactorily to extinguish fires in the vicinity of a salt unit, but vaporizing liquid (carbon tetrachloride), foam, and aqueous types, other than sprinklers or low velocity fog types, should not be used. An adequate supply of clean, dry sand is useful for slagging and diking to confine the spread of escaped molten salt.

If water is purposely or accidentally introduced into a unit that contains HITEC, the heat input should be kept low until all the water has evaporated; the system should be vented adequately to release the steam that is formed.

PERSONAL SAFETY AND FIRST AID

HEALTH HAZARDS

HITEC heat transfer salt is a mixture of sodium nitrite, sodium nitrate, and potassium nitrate. Upon contact, these salts are irritating to the eyes and skin. However, the principal health hazards of HITEC are (1) the thermal and oxidizing burn potential of the molten salt when in use, normally at 300-1000°F (149-538°C); and (2) the toxic effect of the sodium nitrite component if HITEC is swallowed. Trace amounts of sodium nitrite (40% of the HITEC salt) are not considered harmful when taken internally. The oral LD₅₀ of sodium nitrite for rats has been reported as 171 mg/kg (Stanford Research Institute, Report No. FDABF-GRAS-084, July 1972). This would be equivalent to 11.5 grams for a 150-pound man. However, because of differences in the metabolism of sodium nitrite by rats and man, as little as one gram may be fatal to humans.¹

SAFETY PRECAUTIONS AND FIRST AID

Persons handling HITEC at room temperature should exercise care to avoid accidental ingestion or contact with eyes or skin. Food should not be permitted in any area where contamination with even small amounts of HITEC could occur. Exposure can be minimized by wearing rubber or plastic-coated gloves and chemical safety goggles. Wash thoroughly after handling. Operating personnel should wear clean uniforms; cloth impregnated with HITEC has increased flammability and can be irritating to the skin.

In case of contact with eyes, immediately flush with plenty of water for at least 15 minutes. Call a physician. For skin, flush with plenty of water. If HITEC is accidentally swallowed, call a physician immediately. Induce vomiting by sticking finger down throat, or by giving salty water (1 tbs per glass) and repeat until fluid is clear. Patient should be kept prone and warm. Administer artificial respiration if necessary.

Molten HITEC, of course, presents the same hazards noted above for HITEC at room temperature. In addition, its sensible heat can cause severe burns. Wear flameproof clothing, face shield and hard hat during any procedure which might cause spattering of a molten salt bath.

In case of contact with molten salt, immediately flush with cold water and call a physician.

STORAGE AND HANDLING

HITEC heat transfer salt is somewhat hygroscopic and should be stored in a dry place to prevent caking. Organic chemicals and readily combustible materials should not be stored with HITEC. In case of fire in the storage area, large volumes of water should be applied to the salt as quickly as possible. Work clothing should not become impregnated with salt, it increases the flammability.

Coastal ships HITEC heat transfer salt in 100- and 150-lb bags and 400-lb (net) nonreturnable fiber drums.

Containers carry the DOT yellow oxidant label. DOT hazard classification: Oxidizing Material.

CUSTOM BLENDED SALTS

Coastal has the capabilities to custom blend heat treating salts for a variety of industrial applications. In special situations, our trained personnel may recommend our Chemtherm series of heat transfer salts, including Chemtherm HTBS, custom blended to revitalize your heat transfer systems.

Coastal specialists have the expertise to test and recommend the proper treating salts for your regular requirements, or special conditions. Testing and specialty salt applications are available upon your request and follow up conference with our heat transfer specialists.

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SERVICES

Coastal Services Division offers the technical expertise, equipment, and trained personnel to handle your heat transfer salt problems 24 hours a day.

Coastal pioneered and developed new techniques of handling both dry and molten HITEC* heat transfer salt. Through the use of specially designed portable crushers, melters and conveyors, Coastal has the capability to handle 3 changes per day, or a total of 120,000 pounds.

Only Coastal offers a quick, safe, economical method of loading heat transfer salt in a molten state. Specially designed portable heaters allow you to remove salt in a molten state, hold it in that state while your vessel is repaired, and then return it without any substantial loss, and with less downtime. Molten salt has successfully been pumped from field heaters and held for several days before pumping back to the original heater.

Coastal is your full service heat transfer specialty company, offering testing of HITEC samples and providing consultation and analytical services to maintain your system in top operating condition safely, economically and efficiently.

HITEC® BRIQUETTE

SOLAR HEAT TRANSFER SALT

HITEC Heat Transfer Salt is also available in an almond shaped briquette form containing no anti-caking agents. This offers the operator an easier, safer, duty free method of handling the product.

Coastal manufactures and packages to specification a heat transfer salt for the solar energy industry. A complete package of services and product includes monitoring the integrity of the salt in the solar plant, making recommendations for treatment and providing loading services for solar heat transfer salt.

NOTES

*Reg. U.S. Pat. & Tm. Off., Coastal Chemical Company

^a W D Powers, ANJ Quarterly Progress Report, September 30, 1957, ORNL-2387 (Classified)

^b As described in ASME paper 56-SA-31 by C.F. Lucks and H W Deem

^c Private communication from H. W. Hoffman, Oak Ridge National Laboratory and Batelle Memorial Institute.

^d Vargaftik, Neimark, and Oleshchuck, Bulletin of the VTI, September 1952, No. 9.

^e Transactions of American Institute of Chemical Engineers, 36.371, (1940).

^f H. W. Hoffman and S.I. Cohen, *Fused Salt Heat Transfer – Part III*, Forced-Convection Heat Transfer in Circular Tubes Containing the Salt Mixture NaNO₂-NaNO₃-KNO₃, ORNL-2433 (1957).

^g Dilatometer method of ASTM-D696-44

^h Private communication H. W. Hoffman, Oak Ridge National Laboratory.

ⁱ Research report No. 2, The National Board of Fire Underwriters (1946) 85 John Street, New York, NY 10007.

^j Gleason et. al. Clinical Toxicology of Commercial Products, Williams and Wilkins, 1969, p. 171.