

A lush green forest with a stream flowing over mossy rocks. The scene is vibrant with various shades of green, from the deep forest floor to the bright highlights on the water and moss. The stream is the central focus, with water splashing and creating white foam as it flows over the large, rounded rocks. The background is filled with tall, thin trees and dense foliage, creating a sense of depth and tranquility.

A BETTER ENVIRONMENT WITH NEXT-GENERATION SOLSTICE[®] ZD REFRIGERANT

Refrigerants

Honeywell

INTRODUCTION

Honeywell Solstice® zd refrigerant (R-1233zd) is a fourth-generation molecule that has excellent performance in its intended applications. After extensive testing and through collaboration with leading companies, Solstice zd refrigerant is now ready to address the challenging environmental needs of different industries like centrifugal chillers, organic Rankine cycles and high-temperature heat pumps.

Solstice zd is part of the Solstice platform of low global-warming-potential (GWP) materials based on hydrofluoroolefin technology, which is exceeding industry standards to maximize energy savings and dramatically reduce environmental impact.

Solstice zd is a EU REACH-registered and U.S. SNAP-listed alternative

to R-123 and R-245fa designed to make a significant contribution to reductions in global warming:

- GWP=1, existing alternative low-pressure refrigerants have GWPs between 850 and 1,300
- Non-flammable
- No impact on ozone depletion

Solstice zd can provide higher efficiency when compared to R-245fa in the renewable heat recovery market and in the waste recovery market in both mobile and stationary applications. Solstice zd, due to its higher capacity with efficiency similar to R-123, is a good replacement in centrifugal chillers and other low-pressure applications.

SOLSTICE ZD: COMPLIANT WITH REGULATIONS

Solstice zd is not listed in either the EU F-Gas, the EU ODS regulations or the EU Restriction of Hazardous Substances (RoHS) directive.

- Not considered to be an ozone depleting substance
- Not considered a fluorinated greenhouse gas
- Not subject to use controls
- Not subject to cap & phase down
- Not subject to de-listing by U.S. EPA
- Not subject to separate waste stream treatment under the EU WEEE Directive

The physical properties, environmental properties, transportation requirements and exposure guidelines of Solstice zd are summarized in tables 1 and 2. Paragraph Style = Body Heading

TABLE 2: TRANSPORTATION REQUIREMENTS AND EXPOSURE GUIDELINES FOR SOLSTICE ZD

Transportation Requirements	
UN Number	UN 3163
Proper Shipping Name	LIQUEFIED GAS, N.O.S. (Trans-1-Chloro-3,3,3-trifluoropropene)
Hazard Class	2.2
Exposure Guidelines	
OEL	800 ppm

TABLE 1: PHYSICAL AND ENVIRONMENTAL PROPERTIES OF SOLSTICE ZD

Chemical Name	Trans- 1-chloro-3,3,3-trifluoropropene
Molecular Formula	(E)CF3-CH=CClH
CAS Number	102687-65-0
Ozone Depletion Potential (ODP-R11=1)*	~0
Global Warming Potential rev 5th IPCC (GWP CO ₂ =1)	1
ASHRAE Std. 34 Safety Classification	A1
Molecular Weight	130.5 g/mol
Boiling point at 101.3 kPa	18.3°C
Freezing point at 101.3 kPa	-107°C
Critical temperature	165.5°C
Critical pressure	3.6 MPa
Critical density	480.23 kg/m ³
Vapor density at boiling point	5.7 kg/m ³
Liquid density at boiling point	1279 kg/m ³
Heat of vaporisation at boiling point	195 kJ/kg
Vapour pressure at 25°C	129.8 kPa
Vapour thermal conductivity at 25°C	10.0 mW/mK
Liquid thermal conductivity at 25°C	76.9 mW/mK
Vapour viscosity at 25°C	11.1 µPa sec
Liquid viscosity at 25°C	470.1 µPa sec

* No impact on ozone layer depletion and is commonly referred to as zero

Reference: Preliminary report: Analyses of tCFP's potential impact on atmospheric ozone; Dong Wang, Seth Olsen, and Donald Wuebbles Department of Atmospheric Sciences University of Illinois, Urbana, IL.

ENVIRONMENTAL

Solstice® zd is a halogenated olefin with a Replace with a GWP of 1. As with all materials, care should be taken to avoid releases into the environment. Follow all applicable regulatory guidelines when treating or disposing of wastes generated from the use of this product.

TOXICITY

Overall results from a series of genetic studies indicate that Solstice zd is non-mutagenic and non-teratogenic. Based on extensive toxicity testing, the Workplace Environmental Exposure Level (WEEL) committee of the American Industrial Hygiene Association (AIHA) has established a TWA (8 hour time weighted average) exposure level of 800 ppm. Anyone who uses or handles Solstice zd should carefully review the SDS and product label prior to use.

MATERIALS COMPATIBILITY

Honeywell does not recommend the use of chlorinated solvents to clean refrigeration systems or components.

PLASTICS AND ELASTOMERS

Solstice zd is compatible with most common materials. Since there are many different grades and formulations of these materials, we recommend that compatibility testing be performed on the specific grade of materials under consideration and at the conditions of use when designing new systems. The table below contains materials compatibility data resulting from tests performed by Honeywell (testing conditions: two weeks liquid immersion at room temperature). This data should be used only as a guide to the compatibility of materials with Solstice zd. The rankings in the table should be used with caution since they are judgments based on limited samplings. Customers should consult the manufacturer or conduct further independent testing.

FULL IMMERSION STUDY OF COMPATIBILITY WITH SUBSTRATES

SUBSTRATE	AVG. % CHANGE IN HARDNESS	AVG. % CHANGE IN WEIGHT	AVG. % CHANGE IN VOLUME
ABS		3.4	3.6
HIPS		23	83
HDPE		1.7	1.2
Polypropylene		5	3.7
PET		0.1	0
Nylon 66		-0.1	-0.1
Polycarbonate		3.5	3
PVC (type 1)		0.1	0
PVDF		0.1	-0.3
PTFE		2.1	3.9
Polyetherimide		0	-0.5
SBR/CR/NBR	26	-19	-29
Viton® **	-6.2	5.6	8.6
Buna nitrile	38	-15	-21
EPDM	41	-28	-27
Epichlorohydrin	-0.7	0.3	-0.5
Silicone	-1.4	-4.1	-5.9
Thermoplastic PU	-2.2	8.6	6.9
Butyl rubber	8.9	1.2	-2.4
Neoprene	4.4	1	0.3
Kalrez® 6375 **	-10	7	11

	Suitable
	Suitable under certain conditions
	Unsuitable

* Although changes in weight, volume and hardness are minimal, fluid discoloration and/or residue suggest the material may not be suitable for some applications.

** Viton® is a registered trademark of DuPont Dow Elastomers
Kalrez® is a registered trademark of the E. I. DuPont Company

STORAGE, HANDLING AND USE GUIDELINES FOR SOLSTICE ZD REFRIGERANT

Before handling the refrigerant, it is essential that you read the Safety Data Sheet (SDS) for Solstice® zd refrigerant. Special attention should be given to section 2 on hazards identification, and section 4 on first aid measures.

Risk assessment and risk minimization in facilities typically require evaluation on a case-by-case basis since facilities may vary from one another in many ways. To assist you in assessing and minimizing risk in association with the use of Solstice zd, a number of general guidelines can be applied.

CYLINDER STORAGE

- Store cylinders in a cool, well-ventilated area with low risk of fire and out of direct sunlight. Ensure that cylinders are properly strapped into place. Avoid dropping, denting or mechanically abusing containers.
- Store on elevated or concrete floors to avoid tank corrosion, and protect cylinders from moisture and rusting during storage.
- Do not store Solstice zd cylinders near sources of open flames and do not allow containers to exceed 50°C.
- Smoking should be prohibited in storage, handling, and servicing areas where Solstice zd is used.

ACCIDENTAL SPILLAGE

Solstice zd is a liquefied gas with a boiling temperature of 18.3°C. In case of accidental spillage, use non-combustible absorbent materials, (e.g., sand, earth vermiculite, diatomaceous earth), to contain and collect spillage (see SDS section 13). Place spilled material in an appropriate container for disposal according to local regulations.

HANDLING

Personal Protective Equipment (PPE)

- Gloves
 - Avoid cloth gloves (possible frostbite in contacting liquid)
 - Incidental liquid contact: wear PVA or neoprene gloves
 - Avoid repeated exposure or prolonged contact
- Eyewear
 - Safety glasses for normal operations
 - If liquid contact is probable, wear chemical safety goggles and self-contained breathing apparatus
- Respiratory Protection
 - None for adequately ventilated work areas
 - For accidents or non-ventilated work situations, wear self-contained breathing apparatus



PERSONNEL TRAINING

A written emergency response plan should exist and be available. In addition, personnel should:

- Know product hazards and have access to SDSs
- Be trained to handle refrigerants and hold appropriate certifications
- Be properly trained and know his / her responsibility in case of an emergency

OFFLOADING PROCEDURE

Because of its properties, the use of Solstice zd requires attention in the equipment and setup.

The very low vapor pressure values require additional steps for offloading cylinders and tanks, compared to other products:

1. Before offloading the product, store the container indoor overnight, if possible
 2. The use of a heating blanket will facilitate the offloading, alone or in combination with 1
 3. The use of a pump is required, alone or in combination with 1 and 2
- Make sure you always operate in a clean safe area.
 - Ensure enough clearance to walk around the container
 - Ensure connections are visible, to allow visual leak check
 - Keep environment noise low, to allow leaks to be audible
 - Do not leave connection hoses suspended
 - Do not step over pressurised hoses
 - Continuously check pressure values during the whole process
 - Read the SDS. A paper copy is included in the shipping documents.
 - Always use PPE, minimally, chemical resistant goggles (eyes) and gloves (hands).

OFFLOADING FROM A 100-LB CYLINDER

Package Specifications	100 lb Cylinder
Product weight (kg)	45.3 kg
Tare weight (kg)	31 kg
Cylinder dimensions	1.3m X 0.3m (Tall X Dia)
Outlet connection	CGA 660 (1.030" 14NGO RH-EXT)



- Weigh the cylinder to verify initial value (tare can vary slightly)
- Position the cylinder in the work area
- An internal dip tubes reaches the lowest point inside the cylinder, to extract all liquid
- Connect the transfer hoses to the valve outlet and the pump, and install a pressure gauge
- Install a sight indicator on the line to process (or pump outlet)
- Open liquid phase valve and start pump, to start the outlet flow; perform a leak check
- If liquid flow stops, please check the following:
 - The cylinder may be empty. This can be confirmed by verifying the weight
 - Check pressure difference (cylinder compared to process)
 - Check the pump for cavitation
- Once the product is transferred completely, close the valve on cylinder
- Depressurise liquid line from cylinder valve to pump
- DO NOT leave liquid-filled piping blocked with no pressure relief
- Disconnect hoses
- Store in suitable storage area
- Return the empty cylinder to Honeywell



OFFLOADING FROM A TON CYLINDER

Package Specifications	Ton Cylinder
Product weight (kg)	900 kg
Tare weight (kg)	645 kg
Cylinder dimensions	2.1 m X 0.8m (Length X Dia)
Outlet connection	CGA 660 (1.030" 14NGO RH-EXT)

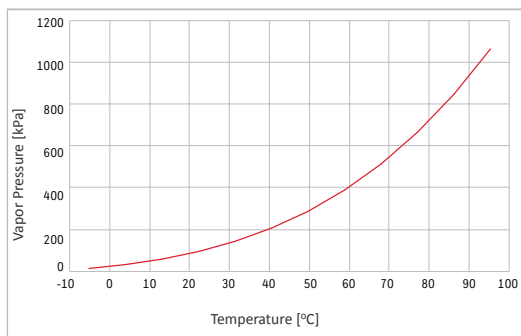
- Weigh the ton cylinder to verify initial value
- Position the ton cylinder in the work area, levelled horizontally, or slightly tilted (lift the end opposite to the valves, about 10 cm)
- Align valves along a vertical line. The valve in the lower position will be the liquid phase
- With the ton cylinder in this position, the dip tubes will reach the lowest and highest points, respectively, for liquid and vapour
- Connect the transfer hoses to the valves outlet, and install a pressure gauge on each side:
 - Connect the bottom valve (Liquid) to pump suction or process pipe
 - Depending on the use, a vapour return line can be connected to the vapour side valve (loop setup)
- Open liquid phase valve to start the outlet flow to process (perform a leak check)
- Install a sight indicator on liquid line to process (or pump outlet)
- If liquid flow stops, please check the following:
 - The ton cylinder may be empty. This can be confirmed by verifying the weight on a scale
 - Check pressure difference (ton cylinder compared to process)
 - If using a pump, check for cavitation
- Once the product is transferred completely, close the valves on ton cylinder
- Depressurize liquid line from ton cylinder valve to process
- DO NOT leave liquid-filled piping blocked with no pressure relief
- Disconnect hoses
- Store in suitable storage area
- Return the empty ton cylinder to Honeywell

TROUBLESHOOTING GUIDE

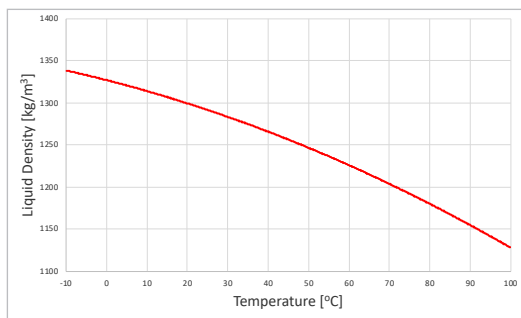
Inability to Empty Cylinder

- Insufficient pressure in the ton cylinder will cause the liquid flow to stop
- Excessive pressure in the ton cylinder leads to expansion across outlet valve
- High pressure in the receiving vessel to which the refrigerant is being transferred
- Low ambient temperatures will increase the liquid density, and make the liquid transfer more difficult
- High ambient temperatures will generate possible expansion through the outlet valve
- Pump cavitations, generated by expansion (high temperature) or density increase (low temperature)
- Attempting to achieve excessive flow rate: dip tubes in ton cylinders are small diameter, as well as the orifice in the valve. Excessive flow rate leads to expansion across the valve.

TEMPERATURE VS. PRESSURE



TEMPERATURE VS. DENSITY



TEMPERATURE [°C]	VAPOR PRESSURE [KPA]	LIQUID DENSITY [KG/M3]
-10	30	1343.7
0	48	1321.3
10	73	1298.3
20	108	1274.8
30	155	1250.6
40	216	1225.6
50	293	1199.7
60	391	1172.8
70	511	1144.6
80	658	1114.9
90	833	1083.4
100	1042	1049.7

LEAK DETECTION

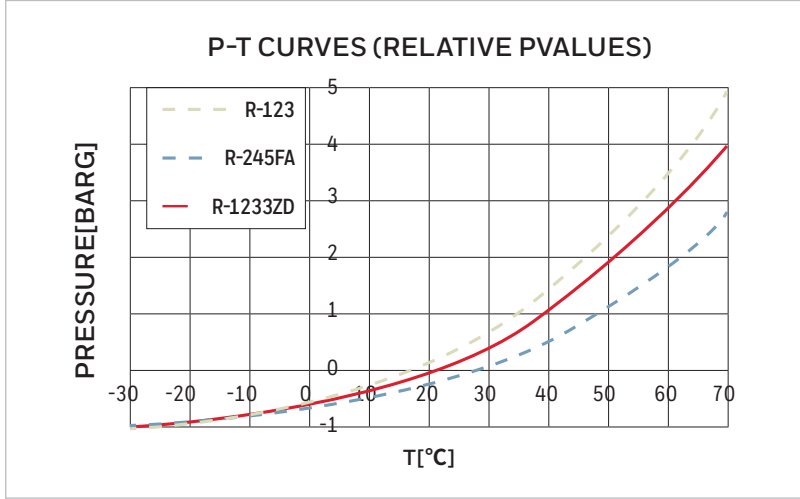
- Periodic leak checks are required during storage
- In the event of a leak exceeding 1.5 vol%, remove personnel and ventilate the area
- Constant monitoring for leaks is required during offloading operations
- Continuous refrigerant leak detection equipment
 - Continuous monitoring systems provide alerts to respond in a timely fashion
 - Detection levels of 1.5 vol% (15,000 ppm) are acceptable.
 - Most continuous monitoring equipment detect very low levels
 - Leak detector performance may vary. Consult the manufacturer
- Handheld or portable leak detectors
 - Valuable for maintenance operations and assembly line workers
 - Detect at extremely low levels (<4 g/year leak sizes)
- Add to scheduled routine maintenance operations
 - Check storage containers for leaks
 - Check piping for leaks

SOLSTICE ZD PROPERTIES

Molar Mass	130.5kg/Kmol
Triple point temperature	-78°C
Normal Boiling point	18.3°C
Critical point	
Temperature	165.6°C
Pressure	3572.6kPa
Density	478.92 kg/m ₃

SOLSTICE ZD COMPARED TO SIMILAR PRODUCTS

	MOLAR MASS [G/MOL]	CRITICAL TEMPERATURE [°C]	NORMAL BOILING POINT [°C]	GWP
R-123	153	183.7	27.8	77
R-245fa	134	154.0	15.1	1030
Solstice® zd	131	165.5	18.2	1



Eurotunnel’s commitment to environmental protection involves a number of initiatives. We saw the replacement of the Channel Tunnel cooling system as a chance to reduce our energy consumption and carbon footprint. This effort required installing a new cooling system—Europe’s largest—to maintain the Channel Tunnel at optimal ambient temperatures. Honeywell’s Solstice® zd refrigerant, with its ultra-low global warming potential, and Trane’s chillers, which are already being used to cool large buildings and infrastructure, provided the best combination of features to help us meet our energy and environmental goals.

François Gauthey
Deputy Chief Executive Officer of Getlink, Channel Tunnel owner

The Series E is part of our EcoWise portfolio of products designed to lower environmental impact with next-generation, low global-warming-potential (GWP) refrigerants and high-efficiency operation – consistent with our company-wide commitment to introduce products that reduce greenhouse gas emissions. These chillers have been successfully used in various applications across Europe and have helped our customers to achieve operational savings while lowering their environmental footprint, without compromising safety, reliability and performance.

Jose La Loggia
Vice President and General Manager of Trane in Europe



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For more information

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