



Novec™ 612

Magnesium Protection Fluid for Die Casting Applications

Introduction

3M™ Novec™ 612 Magnesium Protection Fluid is an advanced, next generation cover gas agent for the protection of molten metals such as magnesium and its alloys. It can replace sulfur hexafluoride (SF₆), sulfur dioxide (SO₂) or hydrofluorocarbons (HFCs) such as HFC-134a in processes requiring protection of molten magnesium. Its wide margin of safety, low environmental impact and efficient protection of magnesium in a wide range of casting, refining and recycling processes make Novec 612 fluid an ideal replacement for current cover gases, such as SF₆ and HFCs.

The long-term sustainable solution

Novec 612 fluid was designed to address the needs of the magnesium industry for an SF₆ replacement that is safe, efficient, and broadly applicable to all magnesium alloys and processes, and not subject to significant regulatory restrictions or scheduled phase-outs. With zero ozone depletion potential, short atmospheric lifetime and a global warming potential of 1, Novec 612 fluid offers a viable, sustainable cover gas agent for molten magnesium protection. As such, Novec 612 fluid is an ideal replacement for SF₆, SO₂ or HFCs in the magnesium industry.

Safe, efficient, and environmentally acceptable

Novec 612 fluid is used at low concentrations (0.01 to 0.05 volume %) in conventional carrier gases such as dry CO₂ or N₂. Air (5-20%) is added to provide the oxygen to produce the MgO needed for a stable protection film. The resulting protective film on the surface of the magnesium melt is stable and silver to gray in color. It minimizes excess oxidation of metal and prevents the white MgO dust normally seen with SF₆/air cover gases. It will efficiently control or extinguish small spot fires should they occur after excessively long open times.

Novec 612 Fluid and Use Concentration Comparison

Not for
specification
purposes

Properties	Novec 612 fluid	SF ₆	SO ₂	HFC-134a
Boiling Point °C (°F)	49 (121)	-63 (-83)	-10 (14)	-26 (-15)
Typical Use Concentrations (volume %)	0.01 – 0.1	0.1 – 6.0	0.7 – 6.0	0.05 – 1.0

3M™ Novec™ 612 Magnesium Protection Fluid

Novec 612 fluid is a non-corrosive, nonconductive liquid that quickly evaporates into a carrier gas stream. The liquid and vapor are compatible with materials of construction normally used in current gas mixing, piping and gas distribution equipment. Unlike SO₂ formulations, the low toxicity and high efficiency of the formulated cover gases provide a wide margin of safety for workers. For all practical purposes, the Novec 612 fluid is totally consumed by the molten magnesium surface. Process emissions are minimal, when used as recommended, reducing greenhouse gas emissions to significantly less than 1% of those normally produced with SF₆.

Environmental Properties

Properties	Novec 612 Fluid	SF ₆	SO ₂	HFC-134a
Ozone depletion Potential (ODP)	0	0	0	0
Global Warming Potential (GWP)	1	22,200	1	1300
Atmospheric Lifetime ¹ (years)	0.014	3200	—	140

¹ IPCC Intergovernmental Panel on Climate Change Method 100 Year (ITH)

Use of Novec 612 Fluid as a Cover Gas in Die Casting Furnaces

The use of Novec 612 fluid is different from the use of SF₆ in both the amount of agent required and its distribution over the molten metal because it is much more reactive than SF₆ with molten magnesium. For common die casting alloys, 0.02 to 0.07 volume % Novec 612 agent in carbon dioxide (CO₂) with 5-20% dry air has been found to work well. The higher reactivity of Novec 612 agent also means that it is important to distribute the cover gas evenly in the furnace and to not add significant excess agent, because excess agent can thermally degrade.

Important: Thermal degradation of Novec 612 fluid can produce hydrogen fluoride (HF) and possibly carbonyl fluoride. Because these degradation products can be hazardous to human health (see product MSDS) and corrode process equipment, the following process variables should be assessed so as to minimize thermal degradation of Novec 612 cover gas:

1. Cover Gas Formulation

Novec 612 fluid is a liquid that is easily evaporated into a carrier gas stream. This can be accomplished with either a precision pumping system or a gas bubbler that uses carrier gas to generate a concentrated Novec 612 fluid gas stream (4-10%). This gas stream can be diluted with conventional gas mixers (recalibrated for Novec 612 fluid gas mixtures) to working concentrations of 0.02 to 0.07% by volume. A number of systems have been designed for use with Novec 612 fluid and are available commercially.

Either dry CO₂ or nitrogen (N₂) with 5-20% dry air (at least -40°F dew point) are recommended carrier gases. Slightly higher concentrations of Novec 612 fluid are required with N₂ than with CO₂. The added air provides sufficient oxygen to form MgO in the protective surface film and minimizes formation of unwanted process emissions. The use of dry air alone as a carrier gas is not recommended. The dryness of carrier gases limits the production of hydrofluoric acid (HF). Normally dew points for carrier gases need to be below -40°F for best results. As with any fluorinated cover gas agent, intrusion of water in ambient air when a furnace is opened to add ingots or during pump operation can result in some HF production.

2. Novec 612 Agent Concentration in Cover Gases

The working concentration will vary depending upon the carrier gas (see above), the alloy, surface temperature, specific furnace and lid equipment, general furnace

operating procedures, gas distribution and flow rates. Because of its high efficiency, Novec 612 fluid is best used at low concentrations and high flow rates. (The high efficiency is the result of a higher chemical reactivity than that of SF₆.) In combination with even gas distribution, surprisingly low concentrations of Novec 612 fluid will provide excellent melt protection.

3. Cover Gas Distribution

SF₆ is a very stable material even at molten magnesium temperatures. This low reactivity or low efficiency allowed SF₆ to be used with little regard to distribution over a melt. Single point injection of SF₆ was able to produce good protection because unreacted SF₆ diffused over the whole melt surface.

Novec 612 fluid, however, is much more reactive at melt temperatures and is nearly totally consumed by reaction with the molten magnesium surface. Single point addition of Novec 612 fluid is not effective or efficient, because significantly higher concentrations of agent at high incoming cover gas flow rates are required for satisfactory protection. Excess agent will thermally degrade on hot protected surfaces producing HF and COF₂. The use of excess agent and production of significant HF is referred to as “overprotection.” Overprotection affects both the process economics (significantly more agent consumed) and process equipment (corrosion by HF). In extreme cases, worker safety can be jeopardized by overprotection.

Overprotection can be avoided with an even distribution of cover gas through multiple gas inlets over the melt surface. Where possible, the inlets should be designed to produce a shower of cover gas over the melt. High flow rates and low concentrations are preferred over high concentrations and low flow rates to avoid the tendency of high concentrations to produce overprotection.

4. Dynamic Cover Gas Flow Control

Dynamic control of flow rates also minimizes overprotection and increases cover gas efficiency. Flow rates and concentrations are initially set for an idle furnace. As die casting operations start, additional cover gas is added (by increased flow) to protect the melt as ingots are added and dosing pumps operate. Additional agent is needed to repair the surface film broken during casting operations. Because most die cast cells already have electronic controls (switches) for pumping or automatic ingot addition, it is usually possible to link valves to control the flow of additional cover gas flow for minimal cost. This increases the efficiency of cover gas use regardless of agent used. These added controls help reduce emissions and costs.

Environmental, Health and Safety

Before using this product, please read the current Material Safety Data Sheet (available online or through your 3M Sales or Technical Service Representative) and the precautions and directions for use on the product package. Follow all applicable precautions and directions for use.

Easy Handling and Stable Storage

Novec 612 fluid is a liquid at room temperature and can be more easily handled than a gas. The liquid is pourable because it is low in viscosity and can be pumped with hand, air or electric powered pumps. It is shipped in conventional liquid containers such as drums or pails rather than pressurized containers. This means that it can be shipped by airfreight if needed for rapid refills. Additionally, if a gas leak occurs, the liquid agent can be saved rather than being lost in escaped gases. Novec 612 fluid does not rapidly degrade when exposed to direct sunlight so it must be shipped and stored in closed metal containers. Under these conditions the material is exceptionally stable.

3M™ Novec™ 612 Magnesium Protection Fluid

Materials Compatibility

Novec 612 fluid has been shown to be compatible with typical materials of construction of furnaces and die casting equipment including carbon steel and stainless steel. Gas mixing and cover gas transport equipment materials (carbon steel, stainless steel, aluminum, brass and copper) are also compatible with Novec 612 fluid. Polymeric seals and gaskets in valves and gas mixing meters have also shown excellent compatibility.

Note: 3M recommends that Novec 612 fluid not be used with fluoroelastomer o-rings, gaskets and seals.

Regulatory Status

Novec 612 fluid is registered with no restrictions on its use in, and complies with, chemical notification requirements of the USA (TSCA), Europe (ELINCS), Canada (CDSL), Korea (KECI), Australia (AICS), Japan (METI) and China (CICS).

3M Resources

Novec 612 fluid is supported by global sales, technical and customer service resources, with fully staffed technical service laboratories in the US, Europe, Japan and Southeast Asia.

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