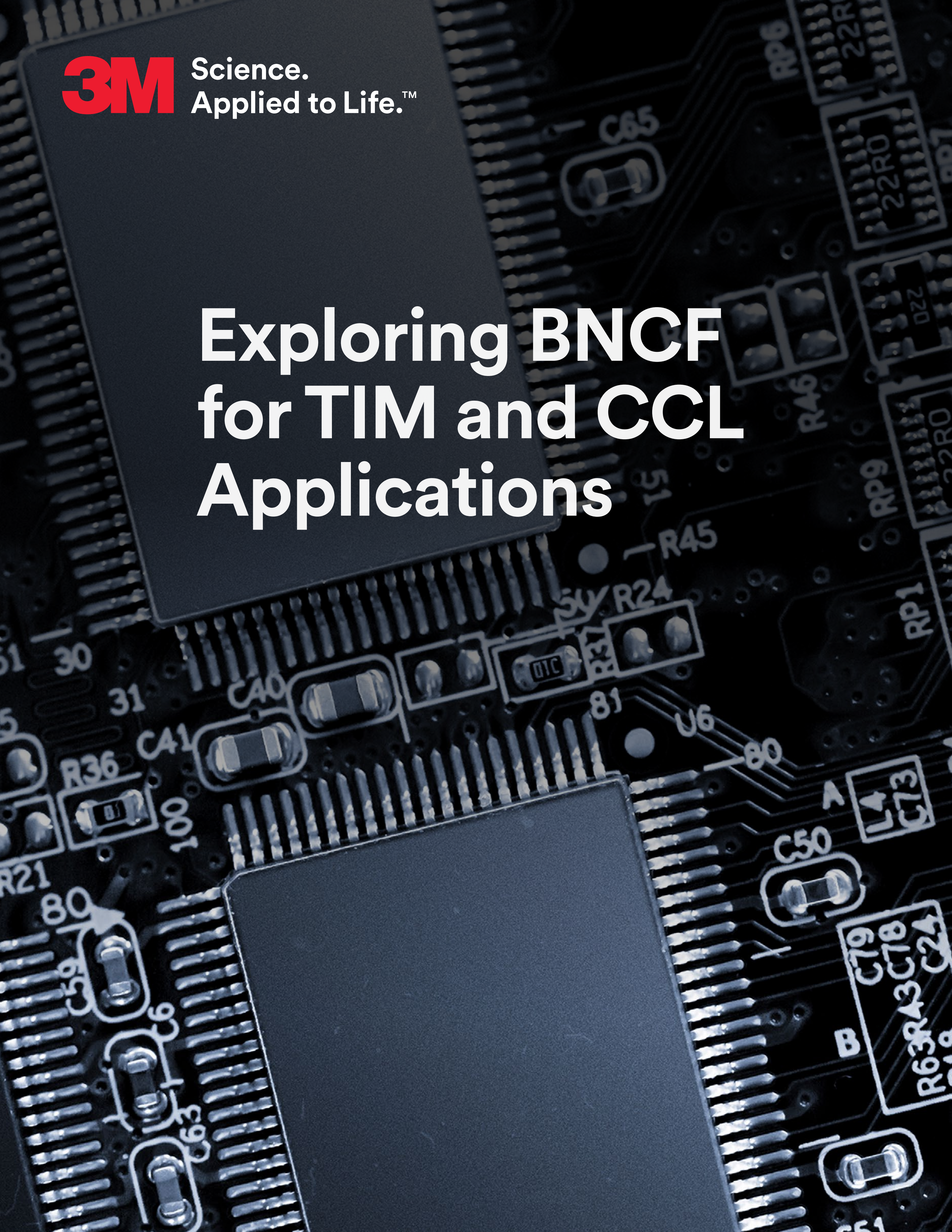
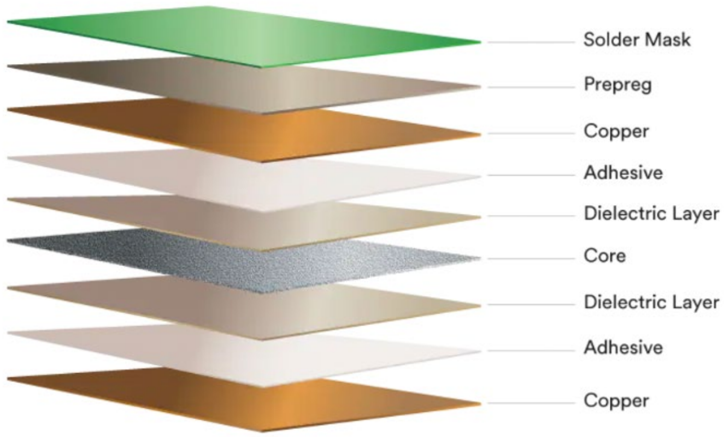


Science.
Applied to Life.™

Exploring BNCF for TIM and CCL Applications

What are Copper Clad Laminates (CCLs)

Copper clad laminates (CCLs) are the foundation to the printed circuit boards (PCBs) used in a wide range of electronic applications across market segments. In some layers of the copper clad laminate, there is an opportunity to improve signal transmission and manage heat with 3M™ Boron Nitride Cooling Filler solutions.



Picture 1: Shows the layers related to CCLs

Where to Find CCLs

Copper clad laminates (CCLs) are crucial in applications where heat management and signal integrity are important. Some specific applications include:

Heat Management Applications:

a. Power Electronics: power supply units, inverters and converters, motor drives, medical devices

b. Automotive Electronics: engine control units (ECUs), battery management systems (BMS)

c. Telecommunications: base stations and antennas

Signal Loss Applications:

a. High-Speed Digital Circuits: data centers, computing devices

b. High-Frequency RF and Microwave Circuits: communication devices, radar systems

c. Telecommunications: networking equipment, 5G infrastructure

d. Aerospace and Defense: avionics, electronic warfare systems

Key Properties for Heat Management and Signal Loss:

a. Thermal Conductivity: High thermal conductivity materials help in efficient heat dissipation.

b. Low Dielectric Loss: Materials with low dielectric loss ensure minimal signal attenuation and distortion.

c. Low Coefficient of Thermal Expansion (CTE): Reduces the risk of mechanical stress and failure due to temperature changes.

Copper clad laminates designed for these applications often incorporate specialized materials and constructions to meet the demanding requirements of heat management and signal integrity.

3M™ Boron Nitride Cooling Fillers are an Excellent Solution for CCLs

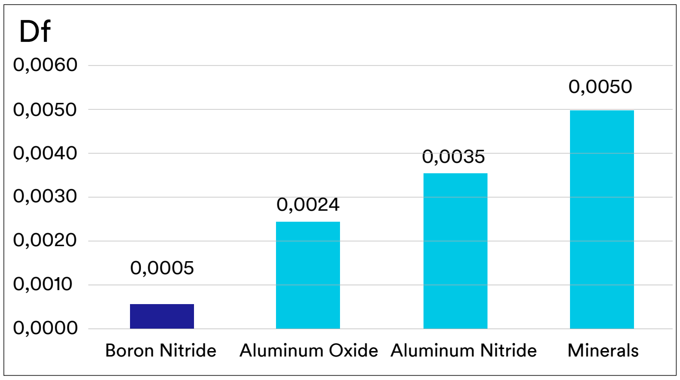
3M™ Boron Nitride Cooling Fillers are low dielectric fillers used in polymer materials to help engineers tailor to a target Dk & Df value while also optimizing thermal properties both in-plane and through-plane for heat dissipation.

Incorporating 3M™ Boron Nitride Cooling Fillers help improve the data transfer velocity and reduce the signal transmission power loss as required in many applications. 3M™ Boron Nitride Cooling Fillers can support the miniaturization of electronics design by enabling production of thinner designs.

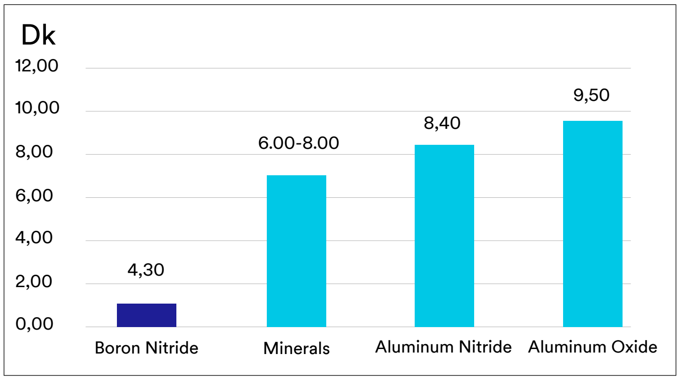
In terms of Dk & Df, 3M™ Boron Nitride Cooling Fillers can offer:

1. Lowest known loss factor (Df) compared to all ceramic fillers with Df of 0.00051
2. Lower known Dk than all other electrically insulating thermal fillers with a Dk of 4
3. When temperature/frequency increases, the Df and Dk of boron nitride stays constant

Loss factor (Df)

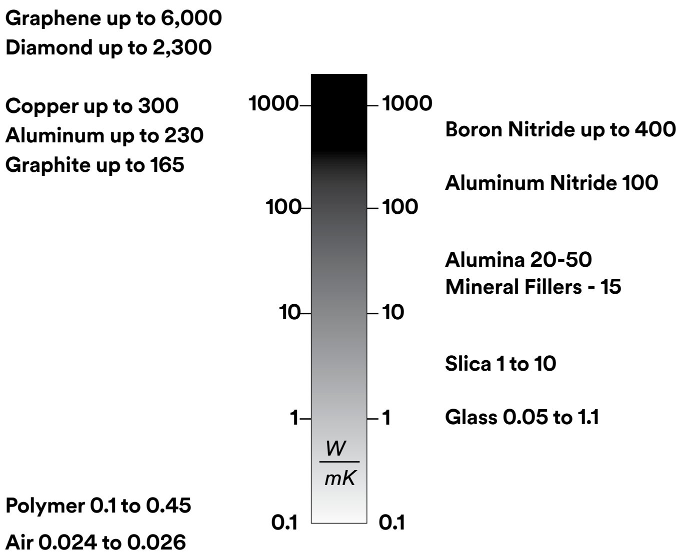


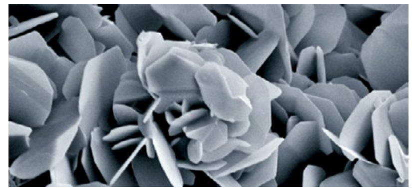
Dielectric constant (Dk)



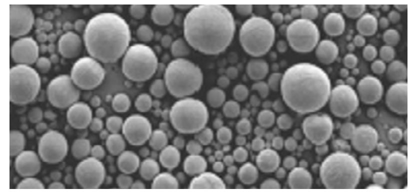
Picture 2: Shows the Df and Dk data of 3M™ Boron Nitride Cooling Fillers

3M™ Boron Nitride Cooling Fillers are 8-20x more thermally conductive than alumina fillers (intrinsic) and 2-8x more thermally conductive when mixed in polymers.

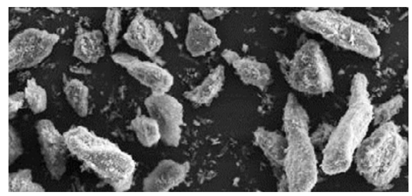




Boron Nitride



Spherical Alumina



Alumina Silicate

Picture 3: Shows 3M™ Boron Nitride Cooling Filler thermal conductivity

Optimal 3M™ Boron Nitride Cooling Filler Solutions for CCLs

The following 3M™ Boron Nitride Cooling Filler solutions are recommended as standard options for initial testing in CCL applications. The particle size distribution of the CFP listed fits well with common CCL solutions across the markets while 3M CFA 50M and 3M CFA 75 are very suitable for applications where through-plane thermal conductivities are the key focus.

3M™ Boron Nitride Cooling Filler Grade	Particle Size Distribution				Bulk Density, Scott	Bulk Density, DIN	Surface Area
	D_{10} (µm)	D_{50} (µm)	D_{90} (µm)	D_{97} (µm)	(g/cm³)	(g/cm³)	(m²/g)
Platelets CFP 001	n.a.	0.5 **	0.5 **	–	< 0.14	–	< 30
Platelets CFP 0075	2 – 3.5	6 – 8.5	6 – 8.5	–	< 0.22	–	< 5.5
Platelets CFP 012	2 – 4.5	8 – 14	8 – 14	–	< 0.25	–	< 4.5
Agglomerates CFA 50M *	5 – 10	15 – 30	15 – 30	–	–	0.1 – 0.4	< 3.5
Agglomerates CFA 75 *	5 – 16	25 – 55	25 – 55	–	–	0.25 – 0.4	< 3.5

Table 1: Shows specifications of 3M™ Boron Nitride Cooling Fillers

Bulk density determined according to ASTM B329/ISO 3923-2 (Scott density) and according to ISO 23145-2 (DIN density).
Particle size distribution measured by laser light scattering (Mastersizer 2000, dispersion in ethanol).

* Particle size distribution measured by laser light scattering (Mastersizer 2000, dry, 0.1 bar)

** Data determined by means of SEM pictures

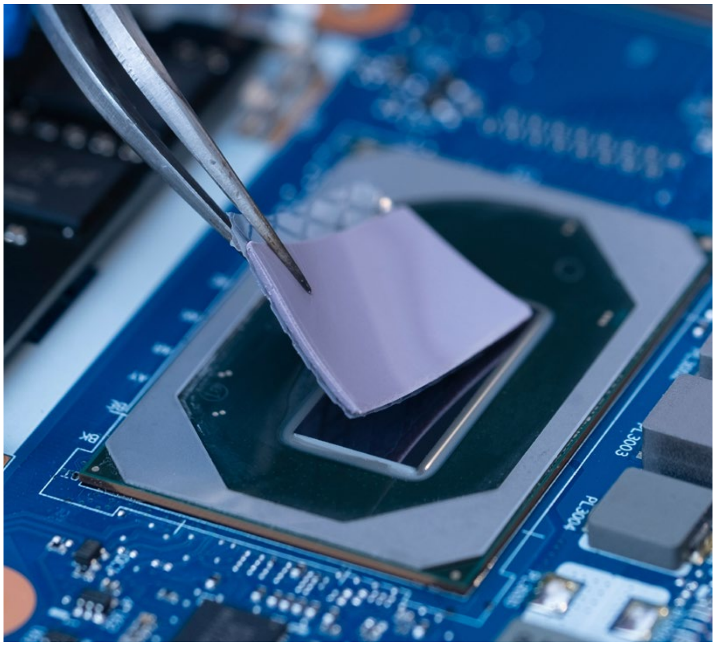
Understanding Thermal Interface Materials (TIMs)

Thermal interface materials (TIMs) are substances inserted between two surfaces to improve the thermal coupling between them. They are used to enhance the heat transfer from one surface to another, which is crucial in various electronic and mechanical systems. TIMs are crucial in electronics, automotive, and other industries where efficient heat management is essential for performance and reliability.

TIM Applications

Thermal interface materials (TIMs) are used in various applications to enhance thermal conductivity between components. Some common applications include:

1. **Consumer Electronics:** Enhancing heat dissipation in smartphones, tablets, and laptops.
2. **Automotive Electronics:** Managing thermal performance in engine control units and battery management systems.
3. **LED Lighting:** Improving thermal management in LED bulbs and display backlighting.
4. **Telecommunications:** Ensuring efficient heat transfer in routers, switches, and base stations.
5. **Medical Devices:** Providing thermal management in imaging equipment and diagnostic devices.
6. **Power Electronics:** Enhancing cooling in inverters, converters, and power supplies.
7. **Industrial Equipment:** Managing heat in motor drives, robotics, and automation systems.



Advantages of 3M™ Boron Nitride Cooling Fillers in TIM Applications

3M offers a full portfolio offering of boron nitride cooling filler additives for your application needs and come in several different form factors including soft agglomerates. In TIM foils and pads, due to their soft structure and purity, 3M™ Boron Nitride Cooling Filler Agglomerates give some of the highest known through-plane conductivity and flexibility in the polymer matrix – enabling TIM designs with the following features:

- High electrical insulation
- Low shore hardness
- High breakdown voltage
- Good peel strength
- High through-plane thermal conductivity from 5W/mK
- Convenient processability

Recommended 3M™ Boron Nitride Cooling Filler Solutions for TIMs

The following 3M™ Boron Nitride Cooling Filler solutions are recommended as standard options for initial testing in TIM applications. Thanks to their controlled particle size distribution, excellent isotropic heat transfer capabilities and excellent adaption to flexible matrix materials, 3M™ Boron Nitride Cooling Filler Agglomerates are optimal solutions for TIM applications.

3M™ Boron Nitride Cooling Filler Grade	Particle Size Distribution				Bulk Density, Scott	Bulk Density, DIN	Surface Area
	D_{10} (µm)	D_{50} (µm)	D_{90} (µm)	D_{97} (µm)	(g/cm³)	(g/cm³)	(m²/g)
Agglomerates CFA 50M	5 – 10	15 – 30	35 – 70	-	-	0.1 – 0.4	< 3.5
Agglomerates CFA 75	5 – 16	25 – 55	75 – 115	-	-	0.25 – 0.4	< 3.5
Agglomerates CFA 100	10-35	50-80	95-145	-	-	0.25-0.4	< 3.0
Agglomerates CFA 125	15-40	75-120	170-220	-	-	0.25-0.5	< 3.0
Agglomerates CFA 150	20-80	120-200	240-360	-	-	0.3-0.55	< 3.0

Table 2: Shows specifications of 3M™ Boron Nitride Cooling Fillers

Bulk density determined according to ASTM B329/ISO 3923-2 (Scott density) and according to ISO 23145-2 (DIN density).
Particle size distribution measured by laser light scattering (Mastersizer 2000, dry, 0.1 bar)

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