WHITE PAPER

CONTROLLING MOISTURE DURING PIPE MANUFACTURING AND HANDLING

Predrag Micic
Product Development Executive
Jonathan Mah
Market Segment Manager
August 2022

Find out why effective moisture management is vital to the quality and performance of polyethylene pipes

The quality and integrity of high-density polyethylene pipelines —especially black HDPE pipe that contains the hygroscopic additive carbon black—can be impacted by even low levels of moisture in the pipe compound. Moisture-related issues include voids, pinholes in the pipe wall or rough pipe surfaces, as well as undermining the quality and strength of butt fusion or electrofusion jointing.

This paper provides an overview of the problems caused by moisture and the main sources of moisture in pipe environments, from raw material handling through to pipe manufacture. Strategies are provided for pipe manufacturers and end users on how to avoid quality issues through effective moisture management.

POLYETHYLENE (PE) IS A HYDROPHOBIC MATERIAL; HOWEVER SOME ADDITIVES SUCH AS CARBON BLACK THAT IS USED AS A UV LIGHT STABILISER AND PIGMENT ARE HYGROSCOPIC AND ABSORB WATER. DEFECTS CAN OCCUR IN THE PIPE WALL IF THE MOISTURE CONTENT OF BLACK PE COMPOUNDS EXCEEDS 0.035 W/W% DURING MANUFACTURE

During extrusion of high-density PE (HDPE) pressure pipe, moisture in the pipe compound can generate steam in the melt exiting the extrusion die due to a drop in pressure. The steam can cause bubbles to form in the melt, which, on cooling, lead to voids in the pipe wall and pitting on the inner surface as shown in Figure 1.

Figure 1. Effects of excessive moisture in pipe compound on PE pipe: voids in the pipe wall (left) and rough surface of inner pipe wall (right).

Experience from the field has shown that a significant proportion of processing issues that affect the appearance of the pipe surface during manufacturing (Figure 2) is caused by excessive moisture content in the pipe compound. The moisture content of pipe compounds can be affected by conditions during manufacture and ambient conditions during storage, transport and use of the pipe compounds.

Figure 2. Excessive moisture in the pipe compound affects the quality of the finished pipe, including the appearance of the outer surface of the pipe wall. Picture shows moisture affected pipe surface during pipe manufacturing between the extruder die and sizing calibrator.

INDUSTRY SPECIFICATIONS FOR MOISTURE CONTENT

Australian Product Standards for pipe compound AS/NZS 4131 includes specifications for moisture content.[1] According to AS/NZS 4131: "When tested in accordance with EN 12099, the volatile content of compounds shall be not greater than 350 mg/kg at the time of manufacture". In practice, moisture content is expressed in % value i.e. 350mg/kg would be quoted as 0.035 w/w% moisture content.

Pipe compounds are tested for moisture at the time of production, but long storage times and ambient conditions can cause the level of moisture to increase. Material management for black pipe compounds is especially important, as there is the potential for moisture pick up at various points in the supply chain.

Different pipe extrusion lines will be affected by the same moisture content in the pipe compound to different degrees. Factors such as the type of extruder, extruder throughput, size of the pipe and its wall thickness influence the sensitivity of the pipe to the presence of moisture. To ensure moisture-free compounds, pipe manufacturers should consider using an effective drying system for the pipe compound before it enters the extruder.

SOURCES OF MOISTURE IN BLACK HDPE PIPES

Carbon black

Carbon black is an important additive in HDPE pipe as it provides UV resistance, protecting the pipe from degradation and loss of properties when exposed to UV energy. To be compliant with the product standard for pressure pipes, carbon black must contain particles that are no larger than 20 nm. According to the literature, compliant carbon black will achieve an equilibrium of moisture absorption of ~3% at a relative humidity (RH) level of 80%.[2] Moisture absorption measurements rely on exposing small samples of the carbon black additive to a moist environment over a defined period, usually 30 days.

Carbon black masterbatch

Carbon black masterbatches typically comprise ~40% carbon black in a polymeric carrier. Therefore, once raw carbon black has been incorporated into the masterbatch, its propensity to absorb moisture is significantly diminished. Moisture absorption test results have shown that for a compliant carbon black type masterbatch, the maximum equilibrium Compound Moisture Absorption (CMA) is ~1.0%.[3, 4]

In practice, the manufacturer of pipe compound and the carbon black masterbatch manufacturer would agree on a specification for the acceptable CMA of the masterbatch that is usually well below the equilibrium value of 1.0%.

Pipe compound

A carbon black masterbatch is blended with the pipe compound to provide a carbon black content of ~2.25%. Once diluted to this level, the maximum moisture content that the masterbatch can contribute to the moisture content of the black pipe compound is ~0.06 to 0.07%. This calculation is based on the 1.0% equilibrium value for CMA for the masterbatch and the common addition rate of the masterbatch during the manufacture of pressure pipe compound.

In an industrial environment, the CMA of freshly made pipe compound would typically range from ~0.015 to 0.020%. However, there are several factors that can affect the CMA of the black pipe compound at the point of use which is the manufacture of the pipe. Significant factors include:

- Package type: bulk or bags
- Method of storage at the pipe manufacturer: bulk or bags
- Storage time between the manufacture of black compound and delivery to the pipe manufacturing site
- Storage times at the pipe manufacturer between acceptance of delivery and the time of usage
- Protection of storage facilities from ingress of moisture, such as rain-proofing, silo loading, well-sealed openings of bags and the location of the storage of the bags e.g., care if placed under roof space
- There are additional considerations for imported black pipe compounds, such as the transportation through regions with fluctuating temperatures and high humidity as well as any repackaging that may have taken place.

HDPE pipe

Once incorporated in the black pipe, carbon black is not expected to pick up moisture at a significant rate because of its low surface exposure to the environment. This low surface exposure is due to the low surface-to-volume ratio of the finished pipe and low content of ~2.25% of carbon black in the pipe. However, extended pipe storage times can result in moisture pick up from the environment to an extent that causes issues during pipe installation. Butt fusion jointing and electrofusion jointing of PE pipes requires heat to melt the pipe compound. If moisture is present at the joint surface, it can create steam which may affect the quality of the joint, as shown in Figure 3.

Figure 3. Example of a butt weld of black PE pipe affected by moisture at the jointing surface.

Typically, installation standards specify that pipe should be installed within 1 year of manufacture, while some industry codes allow 2 years. Experience at Qenos acquired over many years suggests that if well-made pipe is installed during the specified time of 1 to 2 years from manufacture, any additional moisture absorbed by the pipe during storage will not present problems during installation.

Managing moisture

Experience from the field has shown that a moisture content of 0.035 w/w% in the pipe compound will cause pipe surface imperfections during pipe manufacture.

Both the pipe compound producer and pipe manufacturer can minimise the moisture content of black PE pipe using effectively managed logistics for handling materials, including:

- Stock management to prioritise use of old stock (First in first out principle), and avoid inventory build-up
- Bulk management to ensure low moisture pick up between the time of pipe compound manufacture and its use by the pipe manufacturer. Bulk packaging in containers at compound manufacturers and storage of compounds in silos at pipe manufactures enables favourable surface to volume ratio of the pipe compound, minimising moisture pick up.
- Use of containers fitted with single use polyethylene liners to stop moisture ingress into the packaged pipe compound (Figure 4).

Figure 4. Container lined with single-use polyethylene used to transport pipe compound in bulk from the manufacturer to the pipe manufacturer.

> USING AIR FROM A DESICCANT DRYER TO DRY BLACK PIPE COMPOUND IN COMBINATION WITH OTHER MOISTURE-MANAGEMENT MEASURES WILL SIGNIFICANTLY MITIGATE MOISTURE RELATED MANUFACTURING ISSUES.

Imported pipe compounds

There are circumstances where moisture pick up is difficult to manage, especially with imported resin. Shipping containers are often loaded at locations where the air humidity is high. Any moisture from the air that gets trapped in the container may affect the moisture content of pipe compounds, leading to problems during pipe manufacture. The risks of moisture contatamination are increased if containers are held at ports for extended periods awaiting shipment and if the shipment time is long.

Drying

Problems with excessive moisture content in black pipe compound can be managed by drying the pipe compound granules with hot air in a dryer immediately before feeding them into the extruder. The duration of drying and the drying temperature should be optimised so that the moisture content is reduced to 0.02 w/w% or less.

The most efficient type of drying equipment is a desiccant dryer (ambient air is of limited effectiveness to dry materials due to its high relative humidity). A desiccant dryer uses drying agents (usually activated by alumina or silica gel) to absorb moisture from the air stream that is channelled through the dryer. Once the air is dry, it is pushed back out of the dryer as moisture-free air.

Figure 5 shows that the moisture content in air varies with temperature, and therefore the importance of drying pipe compound granules before use, especially in hot humid climates as the maximum moisture content in air affects CMA of the pipe compound. The figure also shows the benefits of heating the air used in a desiccant dryer, as the capacity of air to pick up and hold moisture absorbed from the polymer granules increases at higher temperatures.

Using heated air from a heated desiccant dryer to dry black pipe compound in combination with other moisture-management measures will significantly mitigate moisture related manufacturing issues.

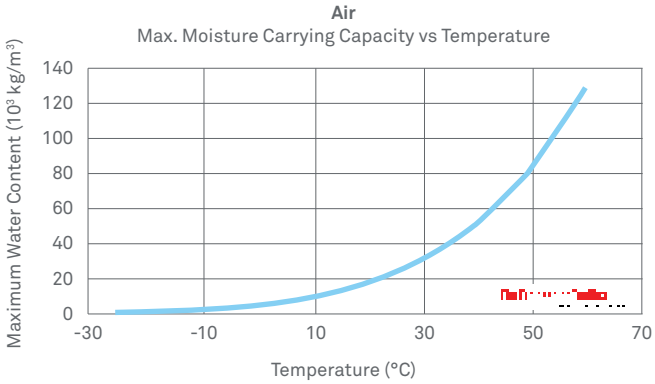

Figure 5. Capacity of air to hold moisture with increasing temperature

HOW THE RESIN MANUFACTURER CAN HELP

- Careful management of supply chain, with produced resin loaded directly into purpose-built containers that are installed with dedicated liners
- Stock management (first in first out) to avoid old stock being used
- Ability to sample and test resin for moisture and provide certification of moisture specification

REFERENCES

1. AS/NZS 4131-2010, Polyethylene (PE) compounds for pressure pipes and fittings, accessed July 2022, https://www.standards.org.au/standards-catalogue/sa-snz/manufacturing/pl-006/as-slash-nzs--4131-2010
2. Cabot Corporation, Moisture adsorption properties of Cabot carbon blacks, Report S-26
3. Carbon Blacks in Pipes, Aditya Birla, Birla Carbon, Published literature
4. Carbon Blacks, Cabot Corporation, Published literature
5. Air - Maximum Moisture Carrying Capacity, accessed July 2022, https://www.engineeringtoolbox.com/maximum-moisture-content-air-d_1403.html

Qenos

Qenos | Ingenious Transformations

Disclaimer

All information contained in this publication and any further information, advice, recommendation or assistance given by Qenos either orally or in writing in relation to the contents of this publication is given in good faith and is believed by Qenos to be as accurate and up-to-date as possible.

The information is offered solely for your information and is not all-inclusive. The user should conduct its own investigations and satisfy itself as to whether the information is relevant to the user's requirements. The user should not rely upon the information in any way. The information shall not be construed as representations of any outcome. Qenos expressly disclaims liability for any loss, damage, or injury (including any loss arising out of negligence) directly or indirectly suffered or incurred as a result of or related to anyone using or relying on any of the information, except to the extent Qenos is unable to exclude such liability under any relevant legislation.

Qenos Pty Ltd
471 Kororoit Creek Rd
Altona Victoria 3018 Australia
Phone 1800 063 573
ABN 62 054 196 771
–
qenos.com