INNOVATIONS FOR LIVING®

FOAMULAR® Extruded Polystrene Insulation
Resisting Water Absorption, the Key for High Performance Foam Plastic Rigid Insulation

Technical Bulletin

FOAMULAR® Extruded Polystyrene Insulation
Owens Corning manufactures a complete line of FOAMULAR® Extruded Polystyrene Insulation (XPS) products for use in residential and commercial construction. The primary difference between FOAMULAR® XPS products is compressive strength ranging from 15 psi to 100 psi. The variety provides common strength products for use in walls where there is almost no compressive load; or, intermediate strength product for use with modest loads such as around foundations, or in low slope roofs; or, high strength product suitable for use under high load floors or plaza decks. The general, FOAMULAR® XPS product line has an R-value of 5 per inch of thickness, while faced sheathing products are available with an R-3 for ½" or R-4 for ¾" thick.

Resisting Water Absorption, the Key for High Performance Insulation
The greatest attribute of FOAMULAR® XPS is its ability to retain R-value and compressive strength even when exposed to water. Insulation products that absorb water lose R-value, and structural integrity. Water is a good conductor of energy, so if insulation is water soaked, R-value is lost. There are two keys for resistance to water absorption: 1) the plastic itself must be hydrophobic (repels water), not hydrophilic (attracts water), and, 2) the cell structure must be truly closed.

Closed Cell: What it Means
Foam plastics insulate by trapping an insulating gas inside millions of tiny plastic bubbles, or, cells. Insulation that absorbs water into the cells loses R-value. A foam plastic insulation that has a closed cell structure absorbs a minimum amount of water thus retaining R-value. Often all foam plastic insulations are referred to as "closed cell". It is important to know what "closed cell" means and then relate it to specific insulation types.

FOAMULAR® XPS viewed under a microscope (Figure 1) shows a homogeneous cross section of very well defined, uniform cells with continuous walls. The cell walls are comprised of hydrophobic (does not bond with water) polystyrene polymer. That combination of characteristics, closed cell/hydrophobic, results in a very low rate of water absorption compared to other types of foam plastic insulation.

Polyisocyanurate insulation (Figure 2), by its nature, has a less well defined cell structure, meaning cells tend to be irregular in shape and size and sometimes blended together. Irregular cells, combined with a hydrophilic chemical tendency (seeks to bond with water) results in higher water absorption compared to XPS.

Figure 1
Extruded Polystyrene Cell Structure

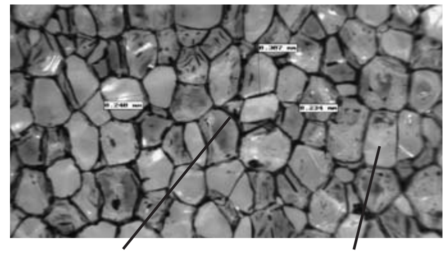


Figure 2
Polyisocyanurate Cell Structure

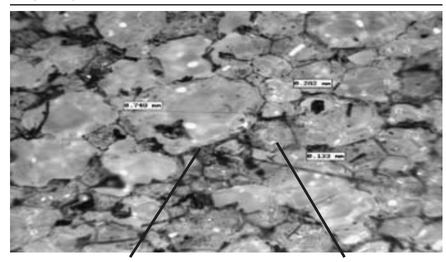
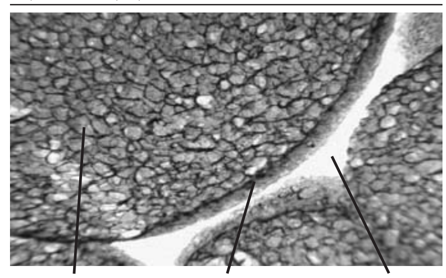


Figure 3
Expanded Polystyrene Cell Structure



Expanded polystyrene (EPS) insulation (Figure 3) is comprised of polystyrene beads fused together under heat and pressure. Although the beads themselves are closed cell and hydrophobic, the air spaces between the beads allow water and air to penetrate the board structure. The air spaces between the beads lower the R-value of the board because air has a higher thermal conductivity than the insulating gas in the cells. The air spaces also provide a path for water penetration, raising water absorption for the complete board.

Comparing Properties: What Do They Mean?

Published properties for different types of insulation are not always directly comparable because different test methods may be used to measure the same properties. If different methods are used to measure performance, identify the differences. They may be significant.

Water Absorption

For example, the material standard that defines properties for all XPS and EPS is ASTM C578.[1] It requires that polystyrene insulation be tested for water absorption in accordance with ASTM C272.[2] C272 requires the polystyrene sample to be immersed in water for 24 hours, and weighed immediately upon removal from immersion to determine the amount of absorbed water.

The material standard for polyisocyanurate is ASTM C1289.[3] It requires that polyiso be tested for water absorption in accordance with ASTM C209.[4] C209 requires the polyiso sample to be immersed in water 2 hours, and drained for 10 minutes before weighing for water absorption.

Figure 4 shows the significant differences in XPS and polyiso water absorption that result

Figure 4

Water Absorption, XPS vs. Polyiso

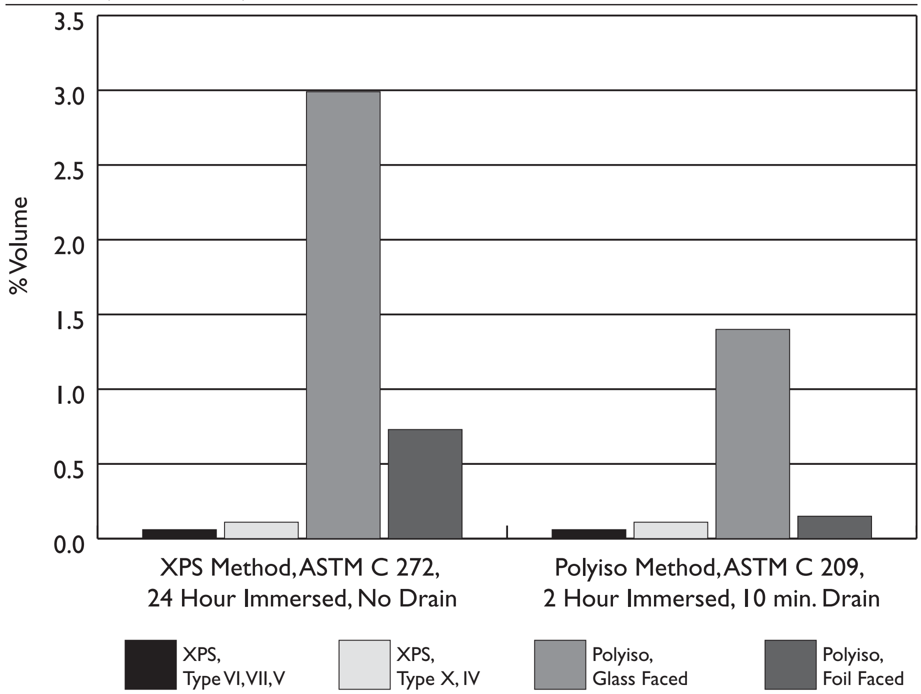


Figure 5

Water Absorption, XPS vs. EPS

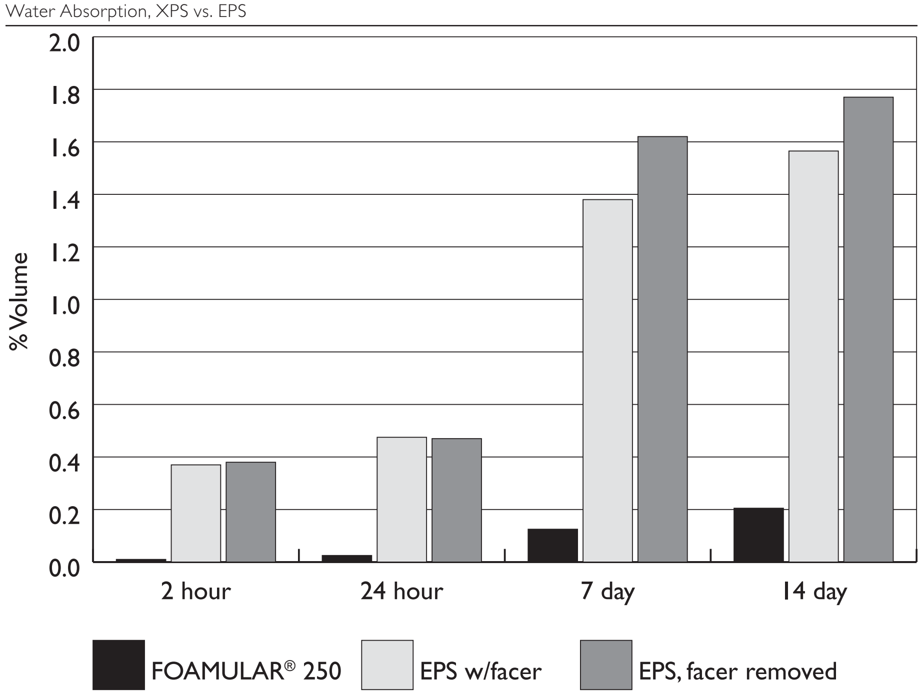


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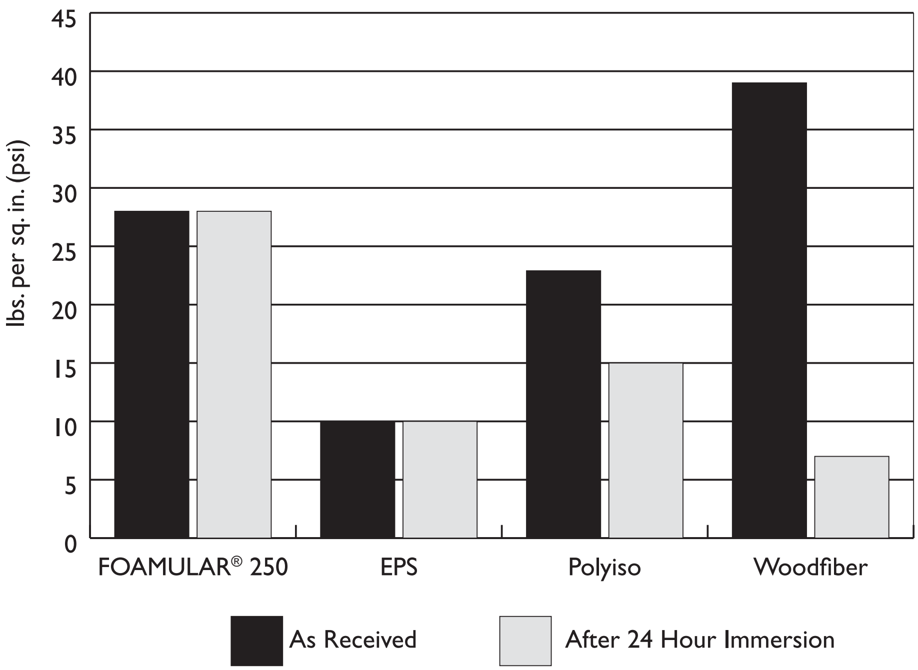
Figure 6

Compressive Strength after Water Immersion



from using different measuring techniques. Note that the water absorption level for polyiso increases greatly when tested by the same method used for XPS. Glass faced polyiso goes from absorbing 14x more water than XPS, to absorbing 30x more water than XPS, when measured using the same method. Foil faced polyiso goes from absorbing 1.5x more water than XPS, to absorbing over 7x more water than XPS. Because the presence of foil makes such a difference in water absorption, the long-term durability of the foil is critical. If the foil is punctured or corrodes while in service, the polyiso core is unprotected from water, and is even more prone to higher water absorption, like the condition with glass facers.

Facers also make a difference in EPS water absorption. Figure 5 shows the significant changes in the water absorption levels of EPS when facers are removed, and when immersion time is increased. Over time, water creeps into the spaces between EPS beads, lowering R-value and raising the risk of beads breaking apart with the expansion forces of freezing and thawing.

Compressive Strength & Water Absorption

Compressive strength may be reduced by water absorption depending on the make-up of the foam plastic insulation, hydrophobic/closed cell XPS or hydrophilic/more open cell polyiso. See Figure 6.

R-Value & Water Absorption

Insulation products that absorb water lose R-value. Water is a good conductor of energy, so if insulation is water soaked, R-value is lost. See Figure 7.

R-Value & Reflective Foil Facers

Some rigid foam plastic insulation products have foil facers on them that some manufacturers claim add R-value to the wall. The presence of a foil surface can add R-value to a wall if two conditions are met.[6]

1. The foil must be adjacent to a sealed air space; and,
2. The air space must be of uniform thickness, bounded by plane, smooth and parallel surfaces.

If these conditions are not met, the foil does not provide any increase in R-value. Most foil faced sheathing is installed under beveled vinyl or other type of beveled siding, and/or, not adjacent to an air space. In such situations, the foil does not provide any increase in R-value.

R-Value & Test Methods

Test method differences may also exist when measuring R-value. R-value changes as foam plastic ages. Long term thermal resistance (LTTR) can be measured using real-time aging, or aging can be artificially accelerated. FOAMULAR® XPS Rvalue of 5/inch is based on real-time 5 year aging. The polyiso industry uses CAN/ULC/S770[7], to accelerate aged R-value. The S770 method has been shown to overstate R-value or LTTR.[8]

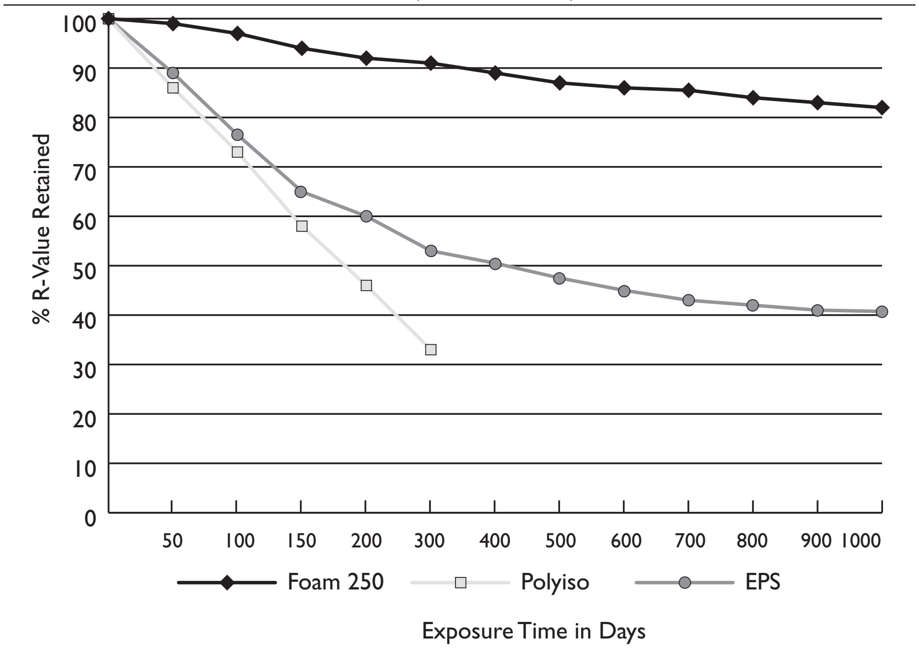
The Misconception of Foam Plastic Insulation as a "Double Vapor Barrier"

If FOAMULAR® XPS is used as sheathing on a wall, doesn't that automatically create a "double vapor barrier", potentially trapping moisture in the wall? The answer is, no. Walls must be assessed for vapor performance. The perception is, 1) liquid water runs off of foam plastic insulation, therefore, 2) it must be water impermeable, and, the misconception, 3) therefore it must be a vapor barrier.

Vapor condenses in walls for three reasons: 1) too much water vapor gets into the wall; 2) it cannot escape out the other side fast enough, and; 3) the accumulating vapor reaches a surface cooler than "dew point" temperature, the temperature at which water vapor condenses to liquid.

The solutions are, 1) limit vapor in with a vapor (barrier) retarder; 2) let vapor out faster than it gets in; and; 3) make surfaces inside the wall warmer using insulation strategies. This is where FOAMULAR® XPS helps.
(Keep in mind this discussion is about vapor PERMEATION only. More moisture gets into walls via AIR LEAKAGE, so, that is even more important to control than vapor.)

Figure 7
R-Value Retained in Roof Insulation after Sustained Exposure to Water Vapor[5]



To control vapor permeation, buildings in heating dominated climates are typically provided a vapor retarder on the "warm in winter" side of the wall. Vapor retarders are designed to limit the permeation of interior moisture vapor into the wall, where it may encounter cooler surfaces and condense to liquid as it moves to the lower vapor pressure outside. Prolonged condensation inside a wall assembly can lead to mold growth.

"Perm" Ratings

A vapor retarder limits the amount of water vapor permeating into the interior side of a wall, so that it is slower going in than it is going out on the exterior side. Comparing the perm rating of the retarder material to the perm rating of FOAMULAR® XPS is the key to understanding why FOAMULAR® XPS is not necessarily a "double vapor retarder".

Although liquid water runs off of, and is virtually unable to penetrate, FOAMULAR® XPS's closed cell structure, molecules of water vapor are another matter. Water vapor molecules can pass between the molecules of any solid material, such as FOAMULAR® XPS. That process is called "permeation". The "perm" rating of a solid material is the measure of how rapidly it allows water vapor molecules to pass. The higher the "perm" rating, the faster water vapor passes through.

Perm rating varies by thickness, decreasing as thickness increases, with the exception that the permeability of facers added to

Figure 8
R-3 Sheathing, Influence on Dew Point Occurrence[9]

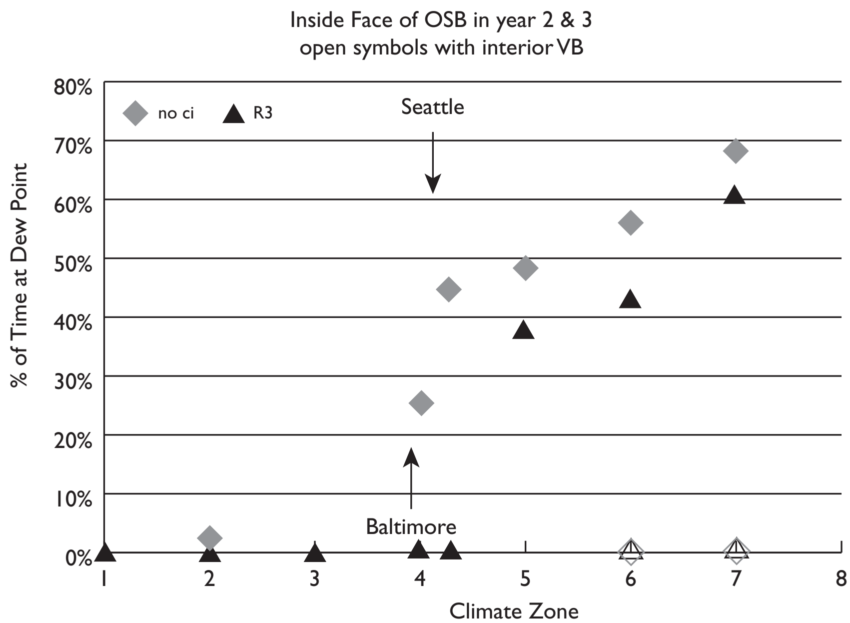
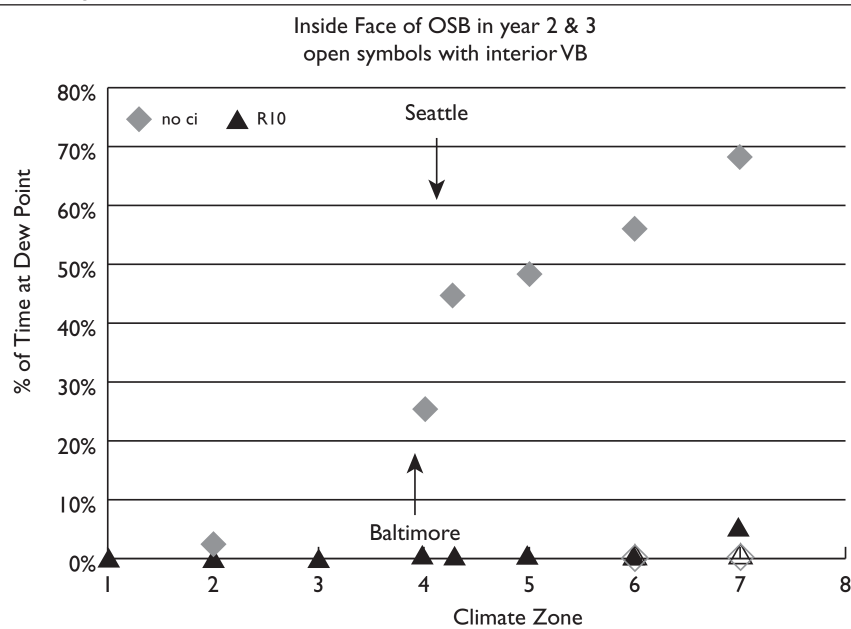


Figure 9
R-10 Sheathing, Influence on Dew Point Occurrence[9]



the board may control perm rating regardless of board thickness. For example, unfaced FOAMULAR® XPS 250, 1" thick, has a rating of 1.1 perm. 2" thick has a rating of 0.70 perm, or, about equal to that of 15/32" oriented strand board sheathing (OSB). Faced FOAMULAR® XPS sheathing, such as IS and **PRO**Pink®, 1" thick, have lower ratings of 0.20 perm.

A common interior vapor retarding material such as 6 mil poly has a rating of 0.06 perm. Using the perm comparison alone, FOAMULAR® XPS (higher perm rating) lets water vapor out, much faster than 6 mil poly (lowest perm rating), lets water vapor in. With that imbalance of inside (lower) versus outside (higher) perm ratings, the possibility of trapped moisture, or a "double vapor barrier, is reduced.

The Effect of Foam Plastic Insulating Sheathing on Dew Point

More importantly, when FOAMULAR® insulating sheathing is used, because it is insulation, it keeps the materials and surfaces inside the wall warmer, thus lowering the occurrence of "dew point" within the wall. Warmer surfaces are more tolerant of water vapor because, at any given vapor concentration, a warmer surface condenses less vapor than a colder surface.

Figures 8 and 9 show dew point occurrence on the inside face of OSB sheathing for walls with R3 and R10 foam plastic sheathing respectively, across all U.S. climate zones from south (i.e., southern Florida, Zone 1), to north (i.e., northern Minnesota, Zone 8). The Figures compare each sheathing condition to the same wall with no "continuous insulation" (ci) sheathing.

Figure 8 shows the predicted amount of time at dew point or below on the interior face of OSB sheathing, for a wall with R13 batt insulation, with and without an interior vapor retarder, and, with and without R-3 insulating sheathing. Figure 9 shows the time at dew point is further reduced if sheathing R is increased from 3 to 10. The data shows that, across almost all climate conditions, walls with insulating sheathing are warmer, therefore spending less time at or below dew point temperature. Therefore, they are less likely to experience moisture accumulation problems.

Both Figure 8 and 9 show the dramatic reduction in dew point occurrence if an interior vapor retarder is used to significantly slow the rate of vapor permeation into the wall.

It is clear from both Figures that, for a properly designed wall, foam plastic insulating sheathing is not a "double vapor barrier" likely to cause moisture accumulation problems. The opposite is true. A given wall, in a given climate, is less likely to have moisture accumulation problems if foam plastic insulating sheathing is used.

Ask Questions. Compare Properties. Understand Building Science.

This bulletin demonstrates the importance of asking questions to insure that published properties are directly comparable, and to understand the relationship of properties to building science. It is important to identify the test methods used to measure properties and if the methods are not identical, ask about the differences.

Moisture and Insulation in Construction

Moisture gets into all types of buildings. Unless the building insulation is highly resistant to water absorption, moisture can degrade insulation R-value, structural integrity, and provide an essential ingredient to support mold growth. Whether it is a home, a commercial retail building, a school building, an office or a freezer building, absorbed moisture is to be avoided to achieve sustainable quality construction. FOAMULAR® XPS is an insulation solution to help achieve that goal.

FOAMULAR® Extruded Polystyrene Insulation

FOAMULAR® XPS Insulation has high resistance to water because it is closed cell and is comprised of hydrophobic polystyrene polymer. It achieves its resistance to water absorption without relying on facers. It has a long term stable thermal resistance of R-5 per inch, measured after real time aging. It is an excellent choice for building insulation applications.

Owens Corning has many insulation and construction products for use in all types of building systems. We have building science expertise to lend to assessing questions on thermal efficiency, moisture management, sound control, air distribution, mechanical and pipe insulation, insulation economics and sustainability.

Contact Owens Corning at 1-800-GET-PINK™, or visit our website at www.foamular.com and www.owenscorning.com.

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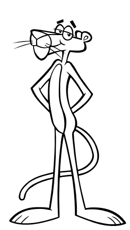

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