

# PVC PIPE *news*

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## INSIDE

Trust But Verify

PAGE 2

Hard Data On  
Cold Weather

PAGE 8

PVC Pipe: The Right  
Choice For Trenchless  
Applications

PAGE 12

Pipe Installation  
Training Just Got Easier  
- And Better!

PAGE 13



Figure 1, Greater Edmonton has a population of more than one million. That makes it the sixth largest metropolitan area in Canada.

## THE EDMONTON STORY

BY CRAIG FISHER, P.E.

*Technical Director and Western Regional Engineer*

### INTRODUCTION

Doug Seargeant first gave his account of the Edmonton experience at the 1998 AWWA Annual Conference and Exposition (AWWA ACE). AWWA gave Uni-Bell permission to reprint that report in its entirety, and it appeared in the Spring 1999 issue of the News. (That article may be downloaded from the "Newspaper" section of the Uni-Bell website.) When the AWWA ACE traveled to Canada last year, Doug gave another paper describing in detail one

facet of the Edmonton experience: "PVC Water Distribution Pipe, 25 Years Later." Doug was kind enough to grant Uni-Bell an interview to add to the written record that he has provided through his conference papers.

Uni-Bell is pleased to offer another installment in its ongoing series of utility profiles, in which water professionals share their experience with PVC with their peers.

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## EDMONTON BACKGROUND

Edmonton is the capital city of Alberta. It is a prairie city located about 300 miles north of Alberta's border with Montana. The local economy is resource based: oil, gas, forest products, farming, and ranching. The population of Edmonton is 730,000 and another 270,000 people live in the surrounding metropolitan area.

Epcor Water Services, Inc. (EPCOR) is the water utility that serves the one million people that live in Edmonton and 40 surrounding communities. Figure 2 maps the major components in the EPCOR water system.

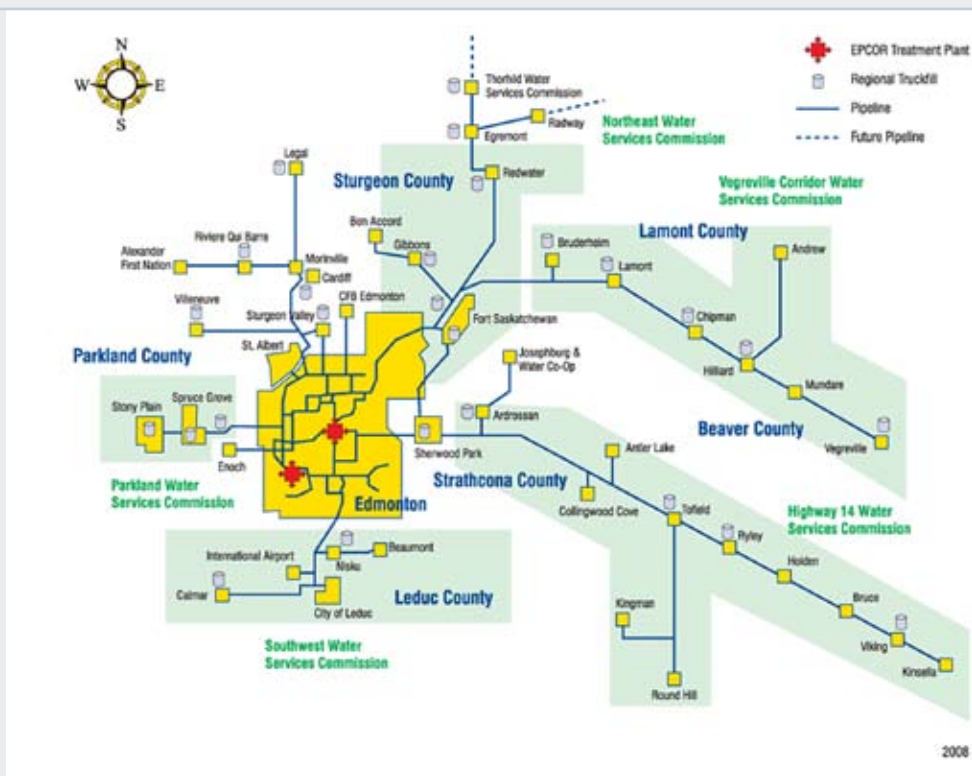


Figure 2, EPCOR Regional Map for Greater Edmonton

**Trust but Verify**  
 Доверяй, но проверяй  
*doveriai, no proveriai*

This Russian proverb was Ronald Reagan's signature phrase during the Intermediate-Range Nuclear Forces Treaty negotiations of the late 1980s, and it is the phrase that comes to my mind when reading the 2007 AWWA conference paper by Doug Seargeant, "PVC Water Distribution Pipe, 25 Years Later." Part of that paper describes the excellent track record that Edmonton has

experienced with its PVC water pipe. (The Edmonton PVC experience is detailed in "The Edmonton Story" starting on page 1.) That track record, however, is a retrospective view. Interestingly, the paper also offers a summary of EPCOR's (EPCOR Water Services is Edmonton's water utility) investigations into what it may expect from its PVC in the future. A successful track record is normally a good indicator of future performance - but not always. In determining whether or not EPCOR should trust that the relatively trouble-free performance of its PVC will continue, it gathered data for verifying this hypothesis by testing some of the oldest PVC in its water system.



A few statistics will put into perspective the physical assets needed to serve a population this large:

- Pipe: Over 3,200 km (More than 2,000 miles)
- Water Meters: Over 230,000
- Hydrants: Over 15,000
- Reservoirs: 12
- Water Treatment Plants: Two
- Average Daily Demand: 365 ML (More than 96 million gallons)
- Daily Capacity: 530 ML (140 million gallons)

### PIPE MATERIAL PREFERENCES

As Edmonton grew, and as other pipe materials and manufacturing processes became available, the utility's preferred pipe material changed. Figure 3 tracks that preference over time.

**PIT CAST IRON:** Edmonton's water distribution system began in 1903 and consisted of 10.5 km (6.5 miles) of cast iron pipe. The type of cast iron pipe installed

### Timeline of the Evolution of Edmonton's Preferred Water Pipe Material

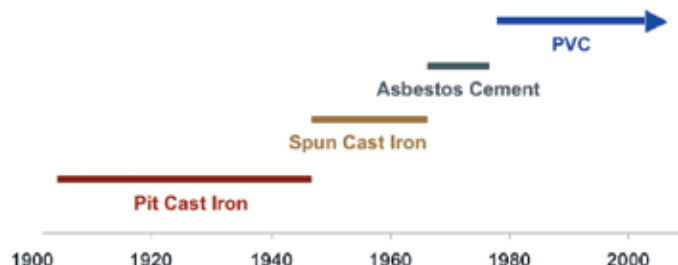


Figure 3, Pipe Material Timeline

would now be referred to as "sand cast" or "pit cast". The original system had 50 fire hydrants and a 330,000 liter (87,000 gallon) elevated storage tank and served 4,176 customers. From 1903 until WWII, pit cast iron pipe was the City's pipe material of choice. This type of manufacturing process produces a comparatively thicker walled pipe.

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Two rounds of testing were conducted. The first round was carried out in 1994 and the second in 2005. The full battery of tests required by the AWWA C900 standard was conducted, as well as a few others. Figures 1, 2 & 3 show photos of some of the tests performed.

#### 1994 TEST LOCATIONS:

AWWA C900 pipe was first installed in Edmonton in 1977. Thus, the oldest pipe available for testing in 1994 was 17 years old. Two locations in the southeastern corner of Edmonton with the 1977 vintage PVC were selected. 25-foot lengths of PVC were exhumed at each location. One was 8-inches in diameter, and the other was 10-inches. Both exhumed sections had gasketed bell-and-spigot joints.

#### 2005 TEST LOCATIONS:

This time, PVC installed in 1978 in the northeastern corner of the City was selected. As before, one location had 8-inch C900 and the other had 10-inch. A similar length of pipe

was removed at each location, and each section had an intact joint. The pipe was in-service for 27 years prior to its removal.

The AWWA C900 standard requires that brand new pipe pass the following:

- Dimensions are checked per ASTM D2122.
- Pipe is flattened per ASTM D2412.
- Extrusion quality is tested in accordance with ASTM D2152.
- Joints are qualified per D3139.
- Elastomeric gaskets must meet ASTM F477.
- Burst pressure is tested per ASTM D1599.

Results of the dimension measurements are summarized in Table 1 on page 11. Table 2 lists the test results for the other requirements in AWWA C900.

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**SPUN CAST IRON:** The material of choice after 1946 was the latest technology of the day - spun cast iron pipe. The primary feature of the spun casting process was a thinner pipe wall compared to the pipe walls made from the pit casting process. A great deal of spun cast iron pipe was installed post-WWII in Edmonton. As with much of North America, Edmonton experienced high growth rates in the years following the war. These rates shifted into overdrive in the 1950's and 1960's due to the discovery of oil just south of Edmonton. Between 1952 and 1965, the length of the water distribution system doubled. Typical of the times, the spun cast iron installed was unlined and uncoated and did not have cathodic protection.

Edmonton's predominant soil type is clay with soil resistivities ranging from 400 to 10,000 Ohm-cm. These corrosive soils took their toll on the thinner walls of the spun cast iron pipe. As shown in Figure 4, the break rates of the cast iron pipe continued to climb throughout the 1950's and the early 1960's. Most of the breaks were occurring on the younger spun cast iron pipe.

**ASBESTOS CEMENT:** To combat the corrosion problem, the City made a non-metallic pipe material, asbestos-cement (AC) pipe, its new standard in 1965. As a result of a 1970's growth spurt, a great deal of AC pipe was installed. However, due to health concerns with asbestos, the search for an alternate pipe material was on again later that decade.

*On average, the repairs in the iron portion of the water system are 312 times larger than that of the PVC portion.*

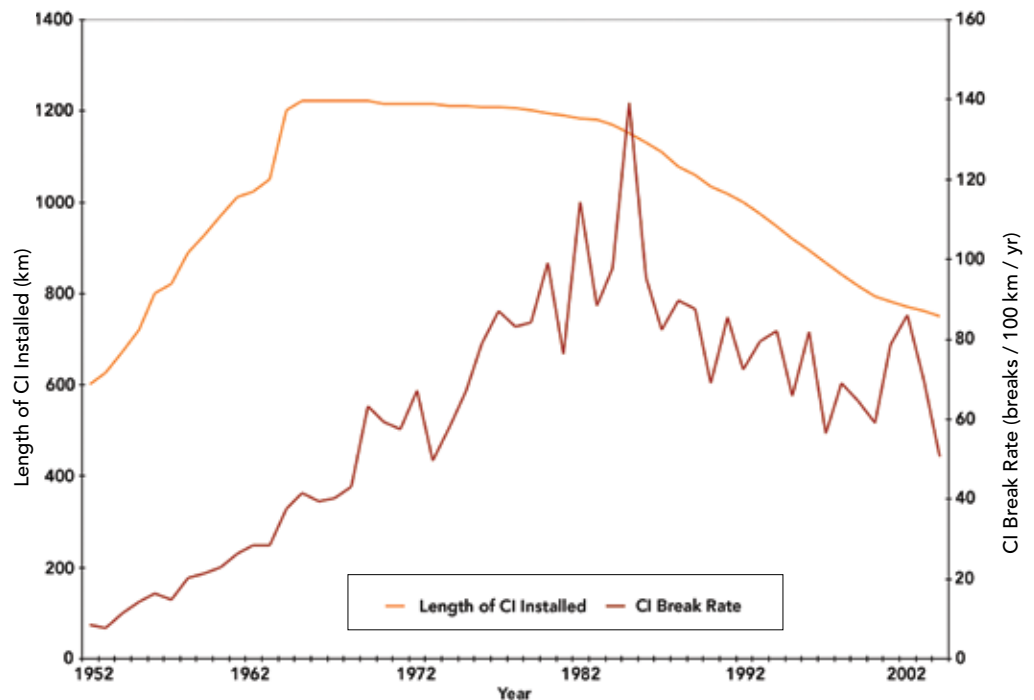


Figure 4, Cast Iron Pipe Performance



Figure 5, Low Resistivity Clay Soils are Corrosive to Unprotected Iron Pipe (Both photos reprinted from *Proceedings of 2007 AWWA Annual Conference*, by permission. Copyright © 2007, American Water Works Association.)

### Edmonton's Pipe Materials (km and percent)

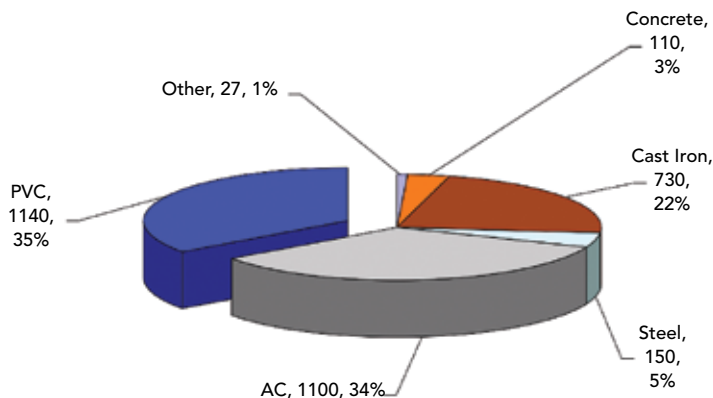


Figure 6, Pipe Materials Used In Edmonton's Water System

**PVC:** The switch to PVC manufactured to AWWA C900 occurred in 1977. Corrosion potential was a key factor considered throughout the decision making process. Figure 4 shows why. The break rates of the cast iron pipe kept increasing during the late 1960's through the 1970's, peaking in 1985. Figure 5 has two photos demonstrating the effects of Edmonton's corrosive soils on the unprotected iron pipe. PVC continues to be the preferred pipe material in Edmonton to this day. At the end of 2006, Edmonton's inventory of buried water pipe totaled 3,250 km (2,023 miles). The net effect of pipe preferences and an aggressive main replacement program commencing in 1986 is shown in Figure 6, which breaks down the inventory of buried pipe by material.

### PVC PIPE PERFORMANCE

One alternative explanation for the poor performance of Edmonton's cast iron water system could be the extreme temperature swings that system experiences. Summer temperatures can be up to 30°C

(80°F), while winter temperatures can be as low as -40°C (-40°F). Raw water temperatures fluctuate between 0.5°C (33°F) and 20°C (68°F). Do frost heave, thermal stresses, and expansion and contraction issues wreak havoc with the PVC portion of the Edmonton water system? Figure 7 indicates that these climatic challenges have not impaired the PVC pipe's ability to deliver superior service. The PVC break rates are two orders of magnitude less than the iron pipe's. (The article, "Hard Data on Cold Weather," on page 8 gives details on PVC's performance in freezing conditions.)

Another possible alternative explanation for the iron pipe performance is age. As pipe gets older, break rates increase. That is certainly the case for metallic systems when corrosion is the failure mechanism, but that does not hold true for non-metallic systems. Note that the failure rate for PVC has not grown as the PVC portion of the water system ages.

Figure 7 also addresses all the other alternative explanations: design, installation, inspection, maintenance. If any of those issues were EPCOR's tragic

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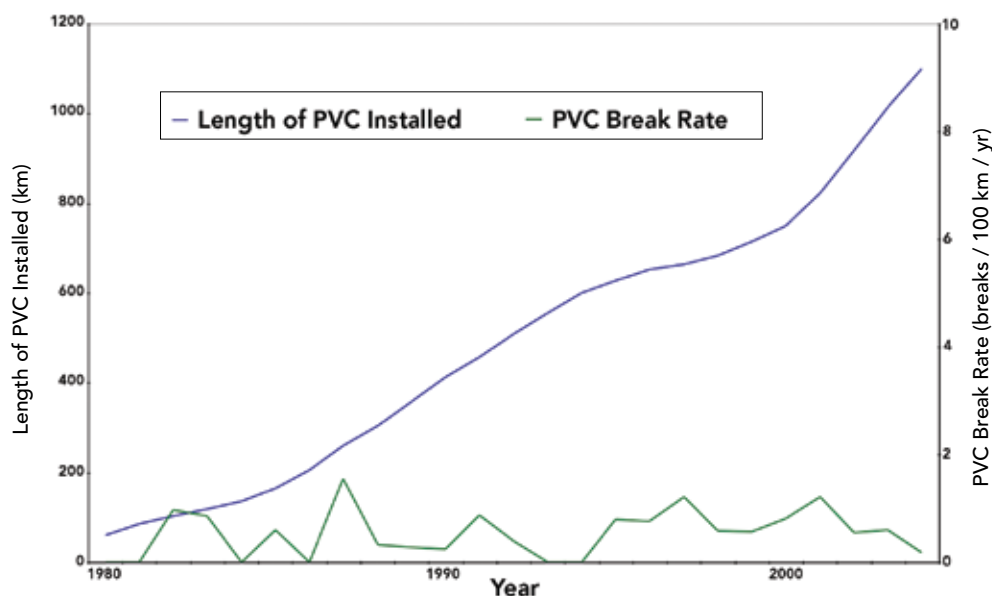


Figure 7, PVC Pipe Performance

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flaw, its experience with PVC would be worse than Canada's overall experience with PVC. The reverse is true. EPCOR's break rate of 0.2 breaks / 100 km / year is 3.5 times lower than Canada's average of 0.7. (Keep in mind, the national average for Ductile Iron is 13.6 times greater.)

When asked to comment on EPCOR's lower break-rate, Doug was extremely modest. He attributed this to the three decades of experience that Edmonton has with PVC water pipe. In this case, the noun "Edmonton" is a broad term that includes the private contractors that install the PVC, the inspectors that help ensure that the job is done right the first time, and the engineers that have fine tuned their standard specifications through the years.

If Figure 7 were the only figure presented, one may come away with the impression that implementing the switch to PVC was problem-free. EPCOR did experience a few minor bumps at the outset. In the first five years, it had a total of five breaks. However, with the small amount of PVC installed, that resulted in some worrisome initial trends. Refer to Figure 8 and Table 1.

Table 1, Data for Figure 8

Year	Cumulative Length of PVC Installed (km)	Breaks	Annual Breaks Per 100 km	Cumulative Avg. Breaks Per 100 km
1977	3.49	0	0.00	0.00
1978	13.14	2	15.22	7.61
1979	43.20	3	6.94	7.39
1980	59.90	0	0.00	5.54
1981	84.89	0	0.00	4.43

*Historical data for the period from 1952 to 1965 for the cast iron portion of the water system.*

*Length Increased from 650 km to 1,220 km*

*Breaks Increased from 50/yr to 500/yr*

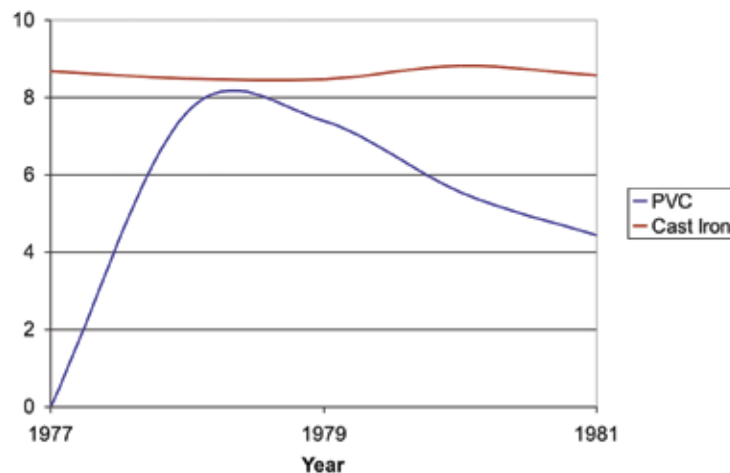


Figure 8, Cumulative Average Water Main Break Rates per 100 km

EPCOR was convinced the product had merit and was determined to give it a fair test. In Doug's words, "You have to expect a few surprises when you are getting to know a new pipe material. Of course, you look at what caused the problem and address it." The downward trend of the cumulative average break rate from 1978 until this day demonstrates that EPCOR conviction of the pipe's potential was well founded.

## EPCOR MAIN REPLACEMENT PROGRAM

While the break rates for PVC trended downward after 1978, the direction of the cast iron break rates did not. Instead of re-plotting the break-rate, Figure 9 shows the total number of cast iron pipe breaks per year (dark red line). As the number of breaks grew, the greater Edmonton community became more vocal with expressing its desire to have the problem fixed, and the City Council heard the message. Doug said "with 1600 breaks in 1985, the problem was approaching a crisis." As a result, City Council asked the water utility to come up with a plan. The response was a proposal to add a 13.5% surcharge on the water bill that would be dedicated to the replacement of cast iron water pipe. The plan was approved and the program began in 1986. Since the inception of the replacement program, EPCOR has replaced about a third of its cast iron pipe inventory. Breaks in the cast iron system have fallen to below a quarter of the peak experienced in 1985.

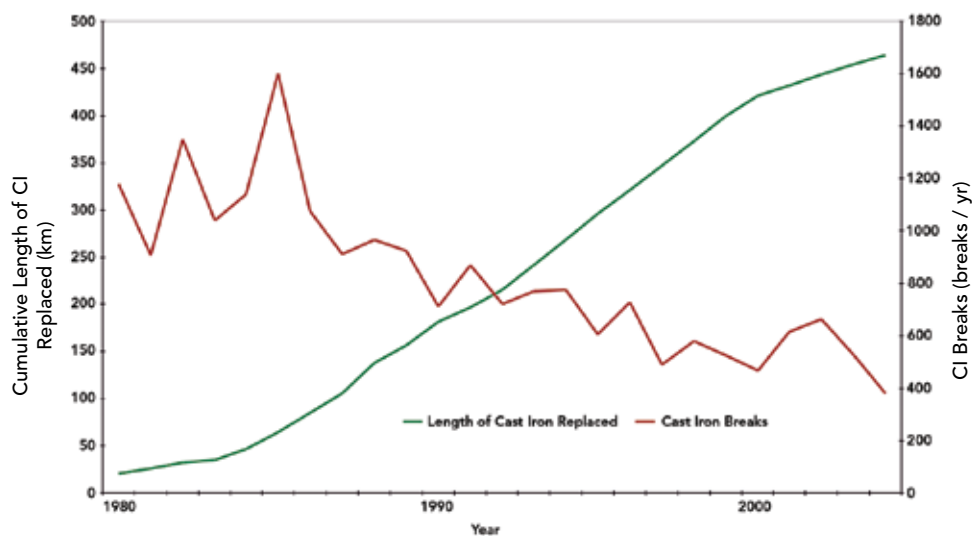


Figure 9, EPCOR's Main Replacement Program

## LEADING THE WAY

EPCOR's comfort with change and technology goes beyond the material used for its water pipe. Edmonton began work on GIS long before it was the fashionable thing to do. The GeoEdmonton Alliance was formed in 1979, which is a partnership between the City of Edmonton and local utilities. By partnering, they avoid the cost of maintaining separate versions of Edmonton's base map and are able to easily share crucial infrastructure information. The Geospatial Information and Technology Association gave EPCOR its Award of Excellence in 2007 and its Innovator Award in 2004.

### Water system data for the period from 1977 to 2005

PVC	Installed length grew from 0 km to 1,130 km.
	A total of 81 breaks in the PVC portion during that period.
Cast Iron	Installed length decreased from 1,220 km to 730 km.
	A total of 24,239 breaks in the iron portion during that period.

EPCOR was the first to use UV disinfection of drinking water on a large scale.

EPCOR uses an Artificial Neural Network (ANN) software program to optimize the water treatment process control system at its Rosedale Water Treatment Plant. ANN is a form of artificial intelligence that simulates the human brain's aptitude for problem solving.

The innovations listed above are a by-product of the EPCOR culture, which truly values and fosters innovation. Evidence of this is demonstrated by EPCOR's involvement in AwwaRF projects, its participation and leadership in professional organizations like AWWA, and its work with the University of Alberta.

The PVC pipe industry is extremely proud to be EPCOR's material of choice for its drinking water system.



*Doug Seargeant is the Director of Water Distribution, Construction and Maintenance for EPCOR. He joined Edmonton's water utility twenty years ago, when it was a City Department. He serves as the Treasurer of Water for People, Canada and actively participates on AWWA's Fire Hydrant Committee and Infrastructure Management Committee. He helped author the sections on potable water systems in Canada's National Guide for Sustainable Municipal Infrastructure.*

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