### How 'bout them Yanks?

Just south of Atlanta lies the sleepy little town of Jackson, Ga. Here, venerable plantation homes offer shelter from the hectic digital world, magnolia groves offer shade from the sweltering southern sun, and the

locals offer to cure all the ills of society with just three words: "Yankee go home."

So it was with some trepidation that Maxine Surfaceblow, a young New Yorker who never traveled anywhere without her Bronx Bombers baseball cap, accepted an assignment at the Greens Ferry generating station on the outskirts of Jackson. The 3400-MW nuclear plant was facing a prolonged refueling outage on one of its units because of failing heatexchanger tubes, and its manager had hired Max's engineering firm, Surfaceblow & Associates, to oversee the repairs. She was a bit worried about how her

northern roots might be received as she greeted the station manager, especially when he eyeballed her Yankees cap.

But Jeb Turner displayed traditional



"If you wanna keep your reactor off-line another week, it's okay with me," Max told the station manager. "But I can plug these tubes and have your operators pullin' rods in 24 hours!"

southern hospitality, welcoming her in that soft Georgia drawl that drops your blood pressure 20 points, and tossing out colloquialisms that stretch your smile. "Ah don't give a dangdilly-dang about where y'all from," he chuckled,

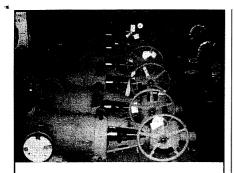
"just so long as you can help me get this heah reactor back on-line."

The reactor was not on-line, even though refueling had been

completed, because 15 tubes in a shell-and-tube heat exchanger had to be plugged. In many powerplants, this is a relatively easy task because both ends of the tubes can be accessed through one of the heat-exchanger heads. But these tubes were in the residual-heat-removal system. Greens Ferry, like many nuclear plants, features a floating-head heat exchanger in this system, which usually means that both heads have to be removed, thus making tube plugging more difficult and time-consuming.

Jeb escorted the visiting





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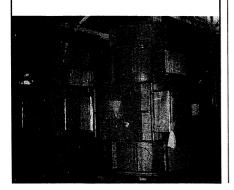
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engineer through the nuclear station's profusion of safety and security procedures, then discussed the repairs with her as they walked toward the maintenance shop. "We ran some eddy-current tests at the start of this refueling outage," he explained, "and identified these 15 problem tubes."

"Leakers?" she asked.

"Goodness no!" he exclaimed, reacting as if Max had just uttered an obscenity inside St. Patrick's Cathedral. "Around heah, we don't let things get to that point." Her host gently explained that eddy-current and other predictive-maintenance tests are performed religiously to track the condition of all heat-exchanger tubes. Slow, ongoing corrosion in these particular tubes had been monitored for some time, and the problem was being attacked now because wall loss had reached 80%—still long before any leaks appeared.

As they surveyed drawings of the heat exchanger, Max and Jeb discussed the various repair options available to them. Station engineers had considered hammering in tapered pins, probably the least expensive option, but rejected that because the method often causes damage to adjacent tubes—especially when beefy, tattooed mechanics are wielding the hammers.

They also explored an option called explosive plugging, but Jeb dismissed that one simply because of the name. "Kin you imagine the rumors them newspaper boys would spread if they found out we were using explosives in a nuclear plant?" he said, his customary grin momentarily turning to a grimace. Like most people working in the nuclear field, Jeb had run up against more than a little bias and ignorance from mainstream journalists.

In the end, the Greens Ferry team decided to use welded plugs. This is generally regarded as the most reliable tube-plugging method, but it would also be the most expensive and time-consuming. At a nuclear station, it would likely produce the most radiation exposure to personnel. For starters, both heads of the heat exchanger would have to be removed—a lengthy process by itself. To get a leak-tight seal, the component next would have to be thoroughly cleaned and then a highly skilled welder would have to meticulously install each and every plug.

Jeb figured it would take about seven days to complete the job. That's why Max was hired—to provide quality control throughout the long process, since the station was short on supervisory personnel during refueling outages.

"I understand what you want from me," Max said with a sigh after she had listened attentively. "But. . . are you really sure you want to do a weld repair?"

"Sure as punkins ain't cauliflower," came the cheerful reply.

The young engineer didn't smile back. Like her famous grandfather, Marmaduke, Max is not known to keep quiet when she thought repair methods could be improved upon. And after a few seconds of silence, she let the station manager know just what she thought.

"If you wanna keep your reactor off-line another week, it's okay with me," she said. "But I can plug these tubes and have your operators pullin' control rods in 24 hours!"

She launched into a well-crafted lecture, with Jeb her skeptical but eager student, about a relatively new technology that allows floating-head tube plugs to be installed with incredible speed and reliability. The technology, referred to as "through-tube plugging," hydraulically pushes a plug through the damaged tube to the far end, from one accessible head. Each plug—a three-piece assembly comprised of a tapered pin, an internally tapered, externally serrated ring, and a breakaway piece—is positioned in the rolled area of a problem tube, within the tubesheet region.

Using a hydraulic ram, the plug's serrated ring is held in place, Max explained, while a center "pull rod" draws the pin through the ring. The drawing action causes the ring to expand until it contacts the tube's inner wall. The ring then slightly deforms along its serrations to form the seal. At a predetermined force, the tensile strength of the breakaway piece is exceeded, and the plug "pops" through the tube—that's why one vendor calls it "pop-a-plug."

Jeb was sold on the technology when the young engineer stated, "Best of all, it's already been proved at other US nuclear stations for just this type of application."

Back in the manager's office, Max contacted the pop-a-plug vendor, who quickly arranged for a technician and all his gear to be on the next flight to Atlanta. With some crisp maneuvering from Jeb, written procedures were revised and signed off by the appropriate authorities, and repairs began early the next morning.

"Jumpin' junipers!" he shouted when the last of the 15 tubes had been plugged within Max's promised time frame. Not only had the procedure cut downtime by six days, but radiation exposure was sliced from the projected 10,000 millirem to only 70.

After satisfactory hydro tests were conducted, Jeb diligently turned his attention toward his next task, reactor startup checks, and his consultant gathered her things to head home. Max was almost out the door when the busy plant manager, remembering his manners, called out to her, "Ma'am, you are welcome back here anytime. But there is one thing I must insist."

"What's that, Jeb?"

"Next time you leave that damn Yankees cap at home. You heah me, Ms Surfaceblow?"

"I heah you," she called out with a laugh, "as sure as the Atlanta Braves ain't World Champions!"

### FLOW FOCUS: PETRO PLUG SEALS SUCCESSFULLY

August, 1998 Vol. IV, No. 7

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The Magazine of Fluid Handling Technology

NU CHUXINE

# Tank Trouble

40 CFR, Part 280

### Aroyou ready? The EPA is

- Recycling process water can save \$\$
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EXPANSION SEAL TECHNOLOGIES 334 GODSHALL DRIVE HARLEYSVILLE, PA 19438

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B P Oil's Alliance Refinery incorporates a variety of shell and tube heat exchanger designs on their Louisiana site. Many of these exchangers have a floating head design, which creates some significant challenges in repairing tube leaks. Although both ends of the tube must be sealed, the floating head design does not incorporate a manway in the shell of the unit to allow access to the far end of the leaking tube. Therefore, effectively plugging leaking tubes in the floating head units had been an ongoing problem for BP's maintenance department.

There are several traditional methods for repairing leaking tubes in floating head heat exchangers. One technique involves the time-consuming process of disassembling the floating head, hammering in a tapered plug, and then reassembling the floating head. Another involves removing the tube bundle from the shell before hammering in a plug, a technique that is both time- and labor-intensive and can cause additional damage to both the tubes and tube bundle if mishandled. A third technique, known as the "lead wool ramming" technique, is carried out by pushing a length of solid backing rod through the tube and ramming pieces of lead wool against the rod to form a plug at the floating head end of the tube. This technique is not always completely effective and at best offers only a temporary solution.

Prior to a recent turnaround, the maintenance department at BP re-evaluated its heat exchanger repair procedures and decided to test an alternative, permanent solution for sealing leaking tubes. Expansion Seal Technologies was contacted and the decision was made to test the patented Petro Plug, a hydraulic implant which can be installed in the far end of a leaking tube after being passed down the length of the tube from the accessible end. The implant, seen in Figure 1, consists of an assembly of three individual components: a tapered pin, a serrated seal-

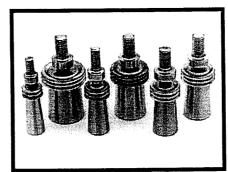


Figure 1

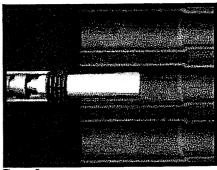


Figure 2a

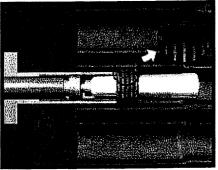


Figure 2b

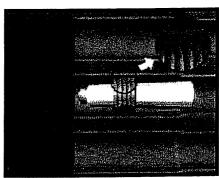


Figure 2

ing ring, and a pulling stud. It is installed using an air-powered hydraulic installation tool and a series of rod and tube assemblies to pass the implant through the tube. When

set, the adjustable standoff ring ensures that the implant will be positioned within the tube sheet region at the far end of the tube. Once the implant and rod and tube assemblies are positioned within the leaking tube, the hydraulic installation unit is attached and actuated. As the piston of the hydraulic unit extends, it pulls the tapered pin of the implant through the ring, causing the ring to expand radially. The swelling ring contacts with the tube wall, and the serrations along its outer surface are compressed against the tube I.D., sealing the tube end. At a pre-established hydraulic pressure, the pulling process is stopped, the piston is retracted, and the rod and tube assembly is unthreaded, leaving the expanded implant within the tube end (Figures 2a-2c).

Sizing of the plug is important. Typically, tubes are affixed to the tube sheets in an exchanger by expanding them with a tube expander. This process produces an inside diameter at the tube sheet that is larger than the inside diameter in the middle of the tube. The plug therefore must be small enough to pass through the middle of the tube, yet have the expansion capability to seal the tube at the tube sheet.

It is also imperative to match the material of the implant with the tube material to eliminate problems associated with galvanic corrosion and different coefficients of thermal expansion in dissimilar metals. In addition, where dissimilar metals are in contact, the more noble materials will deteriorate at an accelerated pace in comparison to the less noble materials.

BP selected a floating head heat exchanger in their catalytic cracker as the trial unit for the Petro Plug. The unit had %-inch O.D. x 16 BWG stainless steel tubes 20 feet in length. The tube sheets were 1-inch-thick carbon steel. A 0.730-inch diameter stainless steel implant was selected and installed.

With the installation a success, the maintenance personnel were able to return both the heat exchanger and catalytic cracking unit to service two full days ahead of schedule. Furthermore, after using the hydraulic implant technique successfully in several additional applications, BP's Alliance Refinery has incorporated the implant into its overall heat exchanger maintenance program.

For Information Circle No. 275

# Floating head heat exchanger tube repair

Hank Brandenberger, Expansion Seal Technologies, USA, introduces a hydraulic solution to the problem of repairing leaking tubes in floating head heat exchangers.

#### Introduction

The majority of shell and tube heat exchangers in a typical refinery are of either a U-tube or floating head design. When tube leaks occur in these heat exchangers, the two types are substantially different in the time required to repair them and return them to service. In order to repair any exchanger, both ends of the leaking tube must be sealed. U-tube heat exchangers allow reasonably easy access to both ends of a leaking tube. Unfortunately, floating head heat exchanger designs are considerably more difficult to repair, as this design does not incorporate a manway in the shell of the unit which would allow access to the far end of a leaking tube.

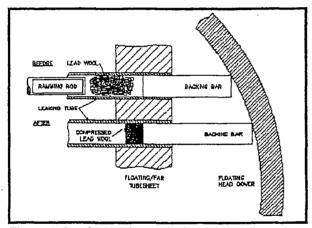


Figure 1. Lead ramming technique.

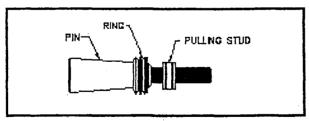


Figure 2. Petro Plug hydraulic implant.

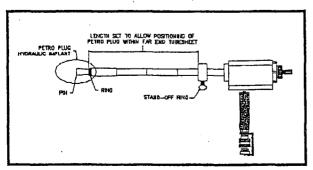


Figure 3. Hydraulic installation tool assembly.

### Repairing leaking tubes

There are several traditional methods for repairing leaking tubes in floating head heat exchangers. One technique involves the time consuming process of disassembling the floating head, hammering in a tapered plug, then reassembling the floating head. Another involves removing the tube bundle from the shell before hammering in a plug, a technique which is both time and labour intensive and can cause additional damage to both the tubes and tube bundle if mishandled. A third technique, known as the 'lead wool ramming' technique, is carried out by pushing a length of solid backing rod through the tube and ramming pieces of lead wool against the rod to form a plug at the floating head end of the tube, Figure 1. This technique is not always completely effective and at best offers only a temporary solution.

### Hydraulic implant

BP Oil's Alliance Refinery, Louisiana, USA, incorporates a variety of shell and tube exchanger designs on site, including many with the floating head design, and effectively plugging leaking tubes in the floating head units had been an ongoing problem. Prior to a recent turnaround, the maintenance department re-evaluated their heat exchanger repair procedures and decided to test an alternative, permanent solution for sealing leaking tubes. Expansion Seal Technologies, USA, were contacted and the decision was made to test the patented Petro Plug, a hydraulic implant which can be installed in the far end of a leaking tube after being passed down the length of the tube from the accessible end. The implant, depicted in Figure 2, consists of an assembly of three individual components, including a tapered pin, a serrated sealing ring and a pulling stud. It is installed using an air powered hydraulic installation tool and a series of rod and tube assemblies to pass the implant through the tube, Figure 3. When set, the adjustable standoff ring ensures that the implant will be positioned within the tubesheet region at the far end of the tube, Figure 4. Once the implant and rod and tube assemblies are positioned within the leaking heat exchanger tube, the hydraulic installation unit is attached and actuated, and as the piston of the hydraulic unit extends, it pulls the tapered pin of the implant

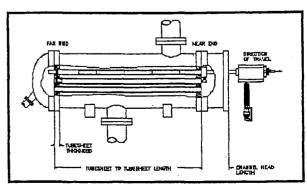


Figure 4. Positioning the implant.

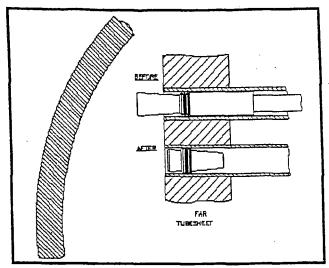


Figure 5. Installation of the Petro Plug hydraulic implant.

through the ring causing the ring to expand radially. As the swelling ring, contacts with the tube wall the serrations along its outer surface are compressed against the tube ID sealing the tube end. At a pre-established hydraulic pressure the pulling process is stopped, the piston of the hydraulic unit is retracted, and the rod and tube assembly is unthreaded leaving the expanded implant within the tube end, Figure 5.

BP selected a floating head heat exchanger in their catalytic cracker as the trial unit. The unit had 7/8" OD x 16 BWG stainless steel tubes, 20 ft in length. The tubesheets were 1" thick carbon steel. A 0.730" diameter, stainless steel implant was selected and installed.

Sizing of the plug is important. Typically, tubes are afixed to the tube sheets in an exchanger by expanding them with a tube expander. This process produces an inside diameter at the tube sheet that is larger than the inside diameter in the middle of the tube. The plug therefore must be small enough to pass through the middle of the tube, yet have the expansion capability to seal the tube at the tube sheet.

Petro Plugs are available in a number of different materials and it is imperative to match the material of the implant with the tube material to eliminate problems associated with galvanic corrosion and different coefficients of thermal expansion in dissimilar metals. When an exchanger is brought up to operating temperature, the tubes slightly expand: this expansion and rate of expansion is dictated by their construction material and the corresponding coefficient of thermal expansion. If the plug is constructed of a different material to the tube, there is a potential for leakage between the plug OD and the tube ID. In addition, where dissimilar metals are in contact, the more noble material will deteriorate at an accelerated pace in comparison to the less noble material.

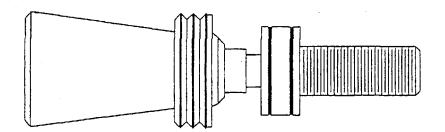
#### Conclusion

The repairs to the heat exchanger at the BP site had been the critical path item during the turnaround and the installation was a success. By utilising this solution, maintenance personnel were able to return both the heat exchanger and catalytic cracking unit to service two full days ahead of schedule.

After using the hydraulic implant technique successfully in several additional applications, BP's Alliance Refinery has incorporated the implant into their overall heat exchanger maintenance programme.

Enquiry no: 47

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## A Million Dollars Saved, And Still Plugging Away.



## A Million Dollars Saved, And Still Plugging Away.



# Through the Tube Plugging in RHR Heat Exchanger Saves in Excess of \$75,000

The Browns Ferry Nuclear Power Plant, located near Athens, AL is a three-unit plant powered by GE/BWR reactors. Currently one unit is in extended shutdown and the other two units are producing approximately 2200 Mwe. This facility is owned and operated by the Tennessee Valley Authority, and began commercial operation in the mid 1970's.

An RHR heat exchanger, designated RHR Heat Exchanger 2B, was scheduled for Eddy current testing during the U2C9 outage. The RHR unit is a vertical, floating head design, with SA-249 #304 Stainless Steel Tubes, 3/4" 18 BWG.

The Eddy current results showed four tubes should be plugged, three of which had greater than 90% wall loss and the fourth tube was at 73% wall loss. The task of plugging tubes in this unit was extremely difficult using the traditional repair method. This involved the removal of the lower head. requiring maintenance staff to use several layers of c-zone clothing, possible facemasks, tents, and HEPA ventilation, due to the very high levels of contamination. These extensive contamination control requirements added to the difficulty of removing the heat exchanger's bottom head in order to seal the tube ends. Using the traditional method, radiation exposure normally exceeds 5000 millirem to complete the repair. Due to the extended length of time this particular exchanger had been in operation, the estimated dose was projected at over 10,000 millirem.

An alternate technology was offered to the Browns Ferry facility by Expansion Seal Technologies of Harleysville, PA. This method eliminated the need to remove the floating head and allowed the designated tubes to be permanently sealed from the accessible end. By removing only the upper head of the exchanger, there are fewer radiological restrictions and a significant reduction in radiation exposure.

By using the EST technology, maintenance personnel were able to complete the repair using only 71 millirem. The savings in manrem alone were in excess of \$75,000.00.

Due to the difficulties associated with the repair, a study was performed by BFN plant personnel, comparing the possible repair strategies and their procedures.

#### **Plugging Options:**

- 1. Do Not Plua
- 2. Perform Plugging as in Past History (drop bottom head)
- 3. Through Tube Plugging-Pop-A-Plug™
- 4. Explosive Plugging
- 5. Resleeving

After the evaluation, the Pop-A-Plug method was chosen. It offers several distinct advantages:

- Cost includes vendor person to install plug while demonstrating method to BFN personnel
- Cost includes purchase of equipment
- Has been successfully performed in nuclear applications

- Demonstration at BFN was impressive per maintenance
- Good reputation among industry contacts
- RHR temperature, pressure, and expansion is within sealing/holding pressure of plug
- Estimated installation time <8 hours</p>
- Will provide assistance to complete QA and code paperwork

#### How the Plug Works

The CPI/Perma plug used in this application is based on the patented high-pressure tube plugging system, P2 (reference proceedings from Fourth BOP Symposium "An Improved Plugging System for HX Tubing"), developed by EST. The plug itself is a three-piece assembly, consisting of the following:

- A tapered pin
- An internally tapered, externally serrated ring
- A breakaway

In near end applications, the plug is positioned in the rolled area of the subject tube, within the tube sheet region. Using an air over hydraulic tool, or manual tool, the annealed ring is held in place, while a center "Pull Rod", draws the pin through the annealed ring. As the pin is drawn through the annealed ring, the ring expands until it contacts the tube ID. The ring then slightly deforms along its serrations. At a predetermined force, the tensile strength of the breakaway is exceeded in the area which has been undercut to a specific diameter, (depending on the size and material construction of the plug), and the plug "pops". For this application, the CPI Perma Plug was ideal. The total time to seal the four tubes was approximately 2 hours. This compares to a minimum of 72 continuous hours if the repair was completed using the traditional repair method. The estimated savings using

#### **Additional Exchanger Applications**

the EST method was over \$100,000.00 (not including management costs) which

included man-rem savings of \$75,000.00.

In addition to the Browns Ferry RHR Heat Exchanger, the EST technology has been used successfully in the following "Through the Tube" applications.

- Turbine oil coolers
- Hydrogen coolers
- Lube oil coolers
- Chillers

This article is a summary of a paper that was presented at EPRI BOP Heat Exchanger NDE Symposium, June 1998 by:

Browns Ferry Nuclear Power Station Tennessee Valley Authority Huntsville, Alabama

Henry Brandenberger Expansion Seal Technologies 334 Godshall Drive, Harleysville, PA 19438

For detailed information about this project, contact Henry Brandenberger at EST-800/355-7044.



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# ENGMAR BICHMARING

A PENNWELL PUBLICATION

SEPTEMBER 1993

Improve water treatment programs

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THE ENGINEERING MAGAZINE OF GENERATION/CONSTRUCTION/RETROFIT/MAINTENANCE

### **Do-it-yourself tube plugs** stop heat exchanger leaks

A do-it-yourself, non-explosive tube plug proved the solution to heat exchanger leaks at South Carolina Public Service Authority's Winyah generating station. At the same time, the new plugs saved up to \$5000 per leakage incident.

The near-weekly heat exchanger leaks ran up downtime and expenses. Under the old system for plugging leaking tubes in the aging high-pressure feedwater heaters, an outside crew was called in to install explosive plugs. The repair was adequate, but the cost averaged \$6000 per visit.

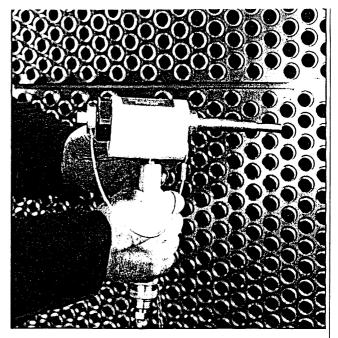
The high cost generated keen interest by mechanical maintenance personnel to find an economical solution. If the work could be done in-house the time spent waiting for the licensed outside crew could

Finally, a non-explosive do-it-yourself plug supplied by Expando Seal Tools, Inc., Montgomeryville, Pa., was tested. Since initial use, about 1100 of the plugs have been inserted. Savings per incident, according to Levon Strickland, maintenance superintendent, are in the range of \$4500 to \$5000.

Also, said Strickland, the heat exchanger is up and running 24 to 36 hours faster when the work is done by in-house mechanical maintenance people. There is no wait for an outside crew to arrive.

The plugs use a mechanical wedge operating principle. They have a tapered pin inside a tapered ring. The ring has 10 to 12 peripheral serrations. As the hydraulic ram draws the pin and expands the ring. each serration forms a seal with the tube wall. The ring is annealed so it neither penetrates the tube wall nor deforms the tube sheet. The plug usually can be installed in the prepared end of a tube within 15

All tubes plugged at Winyah have been copper U-tubes for the



Hydraulic ram tool installs new tube plugs in seconds at Winyah generating station in South Carolina.

high-pressure feedwater heaters. Plug sizes used are 0.450 to 0.490 in.; Monel plugs are used for this application. According to Strickland, various methods of tube preparation were tried. At Winyah, tubes are hand reamed and ends are wire brushed. The plug is then installed by using a hydraulic ram for expansion. Reaming is not required as part of the standard installation procedure, but is necessary for excessively corroded tubes.

Of the 1100 tubes installed thus far, no more than four or five have needed replugging, said mechanical maintenance foreman Linwood Nesmith. In those cases, Nesmith explained, he is convinced the cause was the installation and not the plug itself.

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### **Provides** the **Performance** of Explosive or **Welded Tube** Plugs at Greatly Reduced Cost

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