Monolithic Refractories: Manufacture, Properties, and Selection

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Introduction

API TR 978 is the first in a series of three API technical reports updating the state-of-the-art use of refractory concrete (castables), plastics, and ramming mixes in applications for the Hydrocarbon Processing Industry (HPI). This technical report is complemented by two additional reports in this series:

— API TR 979, *Applications of Refractory Lining Materials*

— API TR 980, *Monolithic Refractories: Installation and Dryout*

These three API technical reports are based on two original reports written by the American Concrete Institute (ACI) Committee 547 and published by ACI in 1979 and 1989. The original ACI reports are ACI 547.R-79, State-of-the Art Report: *Refractory Concrete and ACI 547.1R-89*, State-of-the Art Report: *Refractory Plastics and Ramming Mixes*. ACI granted API a license to use all material from the two original ACI reports, in need of revision at the time, for the betterment of the oil and gas industry.

ACI Committee 547 was organized in 1969 to provide a reliable and comprehensive source of information on monolithic refractories technology. In subsequent years, ACI support from the refractory technical community waned and shifted in favor API. API has an Individual Certification Program (ICP) for refractory practitioners based on the API Standard 936, *Refractory Installation Quality Control-Inspection and Testing Monolithic Refractory Linings and Materials*. To facilitate development of updated content in API's certification program, ACI has allowed API to use the material from the two ACI reports, mentioned above, as the starting point for three new API technical reports, which and add to and revise the content of the two ACI reports.

The American Petroleum Institute formed the Vessel Refractory Task Group in the late 1980s with the objective of providing a standard for inspection and application quality control of monolithic refractories used in refining applications. In response to demands for greater reliability and cycle life objectives, refiners had already developed their own company specifications for refractory installations for the most important applications where unit availability is critical. A cottage industry of supporting quality control experts and inspectors evolved to help owner-operators reduce the gap between ideal and actual cycle life. Prior to the Vessel Refractory Task Group (the predecessor of the SCRM), manufacturers and installers largely had little say in these efforts and uniform industry standards were never developed or adopted.

To address this issue, the Vessel Refractory Task Group allowed for a broad representation of all the stake holders as part of the API's spring and fall Refining Equipment Standards Meetings. Addressing the standards gap and noting the many similarities in owner-operator and OEM developed specifications, the API Task Force undertook the task of identifying useful industry practices and/or negotiating to agreement best fits for standards applications. API's *Refractory Installation Quality Control Guidelines—Inspection and Testing Monolithic Linings and Material* was first issued in 1996 as a recommended practice. After a number of subsequent revisions, it was published as API Standard 936 in 2006, with a certification program beginning in 2004.

In addition to maintaining API Standard 936 and overseeing the certification program, in 2014 the Task Force reorganized under the Committee on Refinery Equipment (CRE) as the Refractory Project Group (RPG). As a project group, work expanded to ceramic fiber and brick quality control standards; unit specific applications, such as SRU and hydrogen furnaces; and technical reports, including this report. In response to this broadening recognition of the need to advance this technology for HPI applications, the CRE reclassified the group as a full subcommittee in 2016 and it now works under the title of the Subcommittee on Refractory Materials.

Monolithic Refractories: Manufacture, Properties, and Selection

1 Scope

This technical report covers the installation and dryout of monolithic refractory lining materials for Hydrocarbon Processing Industry (HPI) applications. It discusses the best practice procedures and techniques used in the installation of refractory concrete, as well as those for air and heat setting plastics and ramming mixes. In addition, it addresses the need for curing and dryout procedures to achieve successful results. This instruction is consistent with API Standard 936, which is the HPI industry standard for the installation quality control of monolithic refractories. API 936 also serves as a body of knowledge document for the API certification program for refractory practitioners.

NOTE API TR 979 and API TR 980 are additional reports listed in Section 2, designed to provide a complete discussion of the monolithic refractory subject.

2 Referenced Documents

API 936, *Refractory Installation Quality Control—Inspection and Testing Monolithic Refractory Linings and Materials*

API TR 977, *ASTM C704 Test Variability Reduced to Allow Further Optimization of Erosion Resistant Refractories for Critical Oil Refining Applications* [1]

API TR 979, *Applications of Refractory Lining Materials* [1]

ASTM C16, *Standard Test Method for Load Testing Refractory Shapes at High Temperatures*

ASTM C20, *Standard Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water*

ASTM C24, *Standard Test Method for Pyrometric Cone Equivalent (PCE) of Fireclay and High-Alumina Refractory Materials*

ASTM C92, *Standard Test Methods for Sieve Analysis and Water Content of Refractory Materials*

ASTM C115, *Standard Test Method for Fineness of Portland Cement by the Turbidimeter*

ASTM C129, *Standard Specification for Nonloadbearing Concrete Masonry Units*

ASTM C133, *Standard Test Methods for Cold Crushing Strength and Modulus of Rupture of Refractories*

ASTM C134, *Standard Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick*

ASTM C150, *Standard Specification for Portland Cement*

ASTM C179, *Standard Test Method for Drying and Firing Linear Change of Refractory Plastic and Ramming Mix Specimens*

ASTM C181, *Standard Test Method for Workability Index of Fireclay and High-Alumina Refractory Plastics*

ASTM C191, *Standard Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle*

ASTM C201, *Standard Test Method for Thermal Conductivity of Refractories*