

FCS[®] - Flexible Cement Systems

1. System Description and Benefits

Cement is placed in the annulus between the casing and the formation to provide long term zonal isolation. However, even if the slurry was properly placed during the cementing job, and had initially fulfilled its isolation role, changes in downhole conditions can induce sufficient stresses to destroy the integrity of the cement sheet.

FCS technology is engineeringly approached to improve zonal isolation of the well by controlling and adjusting the mechanical properties of the set cement. With this approach the values of the elastic parameters and amount of expansion are specified to meet the requirement for long term mechanical durability, hence zone isolation.

Characteristics	Benefits
High temperature elastomers with low Young's Modulus	Provide cement elastic properties while maintaining the compressive strength
Particle engineering technology in FCS design	
Low permeability	Superior job quality and zonal isolation performance
Controllable cement expansion	
Good bonding between cement, casing and formation	
Resistant to variation in thermal and mechanical stress	Applicable in geothermal, gas storage, steam injection and unconventional fracturing
Durable and long-term stability	

2. FCS Additives

Product	Code	Form
Flexible Additive	KCM024	Black Grain
DuraCem Additive	KCM044A	White Grain
Expanding Agent	KCM025H	Pale Gray Powder
Expanding Agent	KCM025HC	Pale Gray Powder

3. Typical Properties and Field Applications

FCS technology was commercialized in 2011 successfully and has been applied in various oil and gas fields in the world. It has been proved to be effective in cementing oil or gas wells with the following conditions and properties:

Temperature: BHST 60-662°F (15-350°C)

Density: 8.3 ppg to 23.3 ppg (1.00 – 2.80 g/cm³)

Mix-water: Fresh water

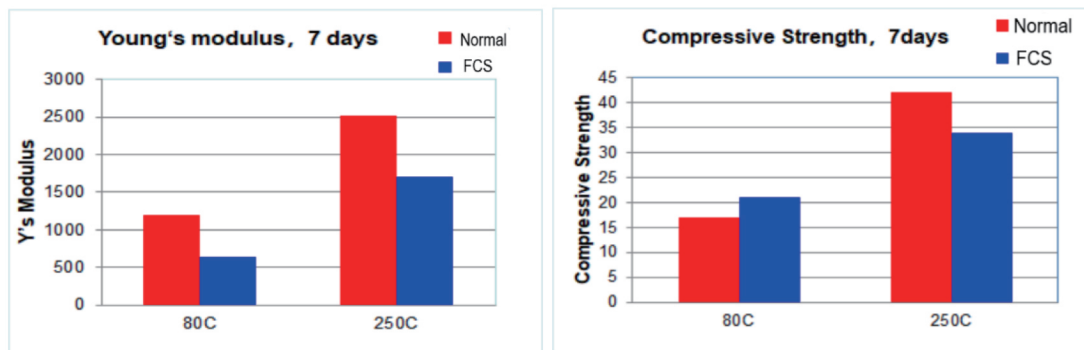
Compressive strength: 20-30 MPa/200°C for 7 days

API fluid loss: ≤50 mL

Treatment Wells: Steam injectors, gas storage wells, geothermal wells, unconventional multi-stage fracturing wells

Further information about field jobs is described in documented "Case History of FCS Technology".

Typical FCS properties are shown in the following Figures and Pictures.



Elasticity and Compressive Strength of Cement Prepared with FCS and Regular Slurry



Normal

FCS

Cement Integrity Prepared with Regular and FCS Slurries

4. Precautions and HSE Considerations

FCS systems include three major additives which are flexible additive KCM024, DuraCem additive KCM044A and expanding agent KCM025H/KCM025HC. Other additives such as fluid loss agent, retarder, dispersant are generally used for controllable rheological, fluid loss, thickening time and stability of FCS cement slurries. Laboratory tests are required to confirm the compatibility between FCS additives and other additives to be used in the slurry.

The laboratory procedures, quality assurance program and guidelines for field mixing and handling of FCS systems are described in FCS fluid manual.

Refer to the technical sheet and SDS of the respective product for the health, safety and environmental information of each product.

Flexible Additive KCM024

1. Introduction

Cement is placed in the annulus between the casing and formation to provide long term isolation between formations. However, changes in down-hole conditions such as temperature, pressure can induce sufficient stresses to destroy the integrity of the cement sheath. Therefore, the mechanical properties of cement sheath must be properly designed to tolerate changes in the wellbore stress due to pressure and temperature changes.

2. Physical Properties and Hazards

Additive	Form	S.G.	Water Solubility	Melting/Flash Point (°C)	Health Hazard	Physical Hazard	pH
KCM024	Black grain	1.53-1.73	Insoluble	>93	Eyes, inhalation	Dust	N/A

3. Chemical Properties and Application

The mechanical properties of set cement are determined by KCM024 concentrations in terms of Young's Modulus. Higher concentration of KCM024 results in lower Young's Modulus value and lower compressive strength. In combination with Particle Engineering Technology (PET), the cement system can be designed to exhibit excellent set properties to meet the well requirement.

KCM024 is a flexible material to modify the mechanical properties of set cement and was developed for gas well, HTHP wells, steam injection wells and wells drilled in tectonically active areas.

4. Treatment

KCM024 is used at concentration between 5% and 30%BVOB (by the volume of blend). Concentration below 5%BVOB does not give sufficient improvement to the cement mechanical properties. Set cement containing KCM024 is stable for long exposure to temperature up to 350°C.

5. Packaging

KCM024 is supplied in plastic-lining bags with net weight of 25kg/sack. It should be stored in shaded areas with good ventilation. Keep it away from high temperature, humidity and direct sunlight.

Expanding Agent KCM025H

1. Introduction

When Cement reacts with water, the system of cement plus water undergoes a net volume diminution, it occurs because the absolute density of hydrated material is greater than that of initial reactants. In the confined environment of a wellbore, the decrease in absolute volume can affect the transmission of hydrostatic pressure to the formation and can affect cement's ability to prevent annular fluids migration.

Good bonding between the cement and casing and between the set cement and formation is essential for effective zone isolation. Cement system that expanding slightly after setting are proven means of sealing micro annuli and

2. Physical Properties and Hazards

Additives	Form	S.G.	Water Solubility	Melting/Flash Point (°C)	Health Hazard	Physical Hazard	pH
KCM025H	Pale gray powder	3.45-3.65	Insoluble	>93	Inhalation	Dust	N/A

3. Chemical Properties and Application

KCM025H is a solid cement additive, which provides cement expansion after setting, tighten cement against the casing and the formation by exerting the compressive forces against both surfaces. This sealing effect prevents and reduces micro-annulus and fluids migration and improves the primary cementing results.

The application temperature ranges of KCM025H is between 93°C and 350°C, the degree of expansion is strongly affected by the temperature and cement system design.

4. Treatment

For the conventional cement slurry system with density of 1.89kg/cm³, typical concentration range is between 1% and 5%BWOC.

5. Packaging

KCM025H is supplied in plastic-lining bags with net weight of 25kg/sack. It should be stored in shaded areas with good ventilation. Keep it away from high temperature, humidity and direct sunlight.

Expanding Agent KCM025HC

1. Introduction

When Cement reacts with water, the system of cement plus water undergoes a net volume diminution, it occurs because the absolute density of hydrated material is greater than that of initial reactants. In the confined environment of a wellbore, the decrease in absolute volume can affect the transmission of hydrostatic pressure to the formation and can affect cement's ability to prevent annular fluids migration.

Good bonding between the cement and casing and between the set cement and formation is essential for effective zone isolation. Cement system that expand slightly after setting are proven means of sealing micro annuli and improving primary cementing result.

2. Physical Properties and Hazards

Additives	Form	S.G.	Water Solubility	Melting/Flash Point (°C)	Health Hazard	Physical Hazard	pH
KCM025HC	Pale gray powder	3.47-3.67	Insoluble	>93	Inhalation	Dust	N/A

3. Chemical Properties and Application

KCM025HC is a solid cement additive, which provides cement expansion after setting, tighten cement against the casing and the formation by exerting the compressive forces against both surfaces. This sealing effect prevents and reduces micro-annulus and fluids migration and improves the primary cementing results.

The application temperature ranges of KCM025HC is between 88°C and 350°C, the degree of expansion is strongly affected by the temperature and cement system design.

4. Treatment

For the conventional cement slurry system with density of 1.89kg/cm³, typical concentration range is between 1% and 5%BWOC.

5. Packaging

KCM025HC is supplied in plastic-lining bags with net weight of 25kg/sack. It should be stored in shaded areas with good ventilation. Keep it away from high temperature, humidity and direct sunlight.

DuraCem Additive KCM044A

1. Introduction

DuraCem additive are generally used to prevent formation fluid migration from occurring. KCM044A is specifically developed to form flow resistance to formation fluids so that the formation fluids cannot migrate during the transition period of cement hydration.

2. Physical Properties and Hazards

Additives	Form	S.G.	Water Solubility	Health Hazard	Physical Hazard	pH
KCM044A	White grain	1.06-1.26	Insoluble	Eyes	Dust	-

3. Chemical Properties and Application

KCM044A can be used for cement slurry design at wide temperature (150-350°C) and density ranges (10.5-20lbs/-gal) due to its unique chemical natures. It can be mixed with freshwater, seawater, and saltwater depend on application requirement.

KCM044A provides superior fluid migration control in cementing gas-bearing formations while maintaining proper rheological properties (PV 10-60cP/YP 1-10 lb/100ft²), fluid loss control (less than 35mL), and accurate thickening time (1-10 hour adjustable).

Lower free water is generally expected for cement slurries containing KCM044A. It is compatible with most cement additives and environmentally friendly.

4. Treatment

1-10% loading is generally required for effective gas migration control depend on temperature, mixing water, and slurry density. Typically, the higher is temperature, the lower is density, the more KCM044A is required for effective gas migration control.

5. Packaging

KCM044A is supplied in plastic-lining bags with net weight of 25kg/sack. It should be stored in shaded areas with good ventilation. Keep it away from high temperature, humidity and direct sunlight.