8.1 OBJECTIVES

The objectives of cementation are to:

- Support and centralise the casing.
- Prevent corrosion of the casing from formation and annular fluids.
- Prevent fluid migration in the annular space between the casing and formation.
- Prevent mixing of water from different aquifers
- Isolate hydrocarbon zones.
- Seal off permeable zones for well abandonment.
- Provide a hard kick off plug for sidetracking existing well track.
- Ensure all regulatory requirements are met.

The following must be followed to ensure a quality cement job:

- Cement slurries must be tested under simulated down hole conditions using samples of water to be used in the cement job. Samples of cement and additives must be taken from the same batch number as the chemicals that went to the site.
- Cementing operations must be carefully planned and controlled to select the correct slurry and to calculate the correct volumes and critical flow regimes required for hole cleaning.
- Slurry and displacement volumes for balancing cement plugs must be carefully calculated to avoid backflow and incorrect placement.
- The drilling fluid and wellbore must be circulated and conditioned before starting cementing operations, to remove cuttings and gas, and ensure optimum rheology for cement placement.
- Mixing, pumping and displacement operations must be monitored to verify volumes are correct and cement slurries are homogeneous.
- Spacers will be used where applicable to avoid contamination.

The following will be used to verify the quality of a cement job:

- Where applicable cement plugs shall be weight or pressure tested.
- A minimum of three samples of each slurry type shall be taken during the cement job.
- A pumping pressure plot of the cement job on Intermediate and Production Casing cementations.
- Cement bond logs may also be run.

8.2 RESPONSIBILITIES

The responsibilities for cementing operations are tabulated below. It should be noted that the specification for each cement job is contained in the Drilling Programme and the DSV shall mobilise the materials and co-ordinate with the Drilling Contractor and Cementing Contractor at the well site.

Task	Performed by	Verified by
Finalise cementing specifications	DM	DM
Prepare detailed work instructions	DSV	DM
Collect water sample	Cementing Contractor	DSV
Test samples and prepare recipe	Cementing Contractor	DM
Prepare well for cementing	Drilling Contractor	DSV
Mix, pump and displace cement	Cementing Contractor / Drilling Contractor	DSV
Conduct rig floor operations	Drilling Contractor / Cementing Contractor	DSV
Prepare end of job reports	Cement Contractor / DSV	DSV

Table 42. Responsibilities for Cementing Operations

The detailed responsibilities for the execution of cementing operations are presented in the following checklist

Prior to job	Description	DSV	Drilling Contractor	Cement Contractor
3-5 days	Send sample of mixing water to the cementing contractor's Laboratory (not required if using Demin water).	X		
2 days	Verify that mix water quality is acceptable			X
2 days	Check Frac tank volume and order water for cement job.	X		
2 days	Confirm BHST from logs. Notify DM if BHST from logs different than that in the Drilling Program.	X		
1 – 2 days	Order Cement	X		
1 day	Receive Contractors Cement Test Report with recipe for cement and spacer from DM.			
1 day	Prepare detailed procedures and work instructions based on final specifications.	X		
1 day	Check chemicals quality and quantity	X		X
1 day	Calculate cement volumes.	X		X
12 hours	Allocate tasks and agree step by step program	X		
12 hours	Complete mix water and spacer checklist			X
12 hours	Check rig equipment (mud pumps, tanks and lines)		X	
12 hours	Check cement equipment (cement unit, head and lines)			
12 hours	Pressure test cementing unit to 500 psi level above expected working pressure	X		
6 hours	Check wiper plugs installed correctly in the cement head	X		X
6 hours	Check safety equipment (dust mask, goggles, earplugs, gloves, eye wash, fire fighting)		X	
1 hour	Attend Pre-job Meeting	X	X	X
	Check hole clean, losses cured, overbalance sufficient	X	X	
	Check mud rheology is within specification.and mud mobility in annulus maximised	X		
	Ensure mud tanks lined up to the cement unit		X	
	Ensure lines pressure tested		X	X
	Complete checklist and verify	X		
	Check water quality from tank prior to mixing cement			X

Table 43. Detailed Responsibilities for the Execution of Cementing Operations

8.3 CEMENTING INGREDIENTS

This section describes the typical ingredients of cement slurries used by GSLM.

8.3.1 Cement

Cement shall be manufactured in accordance with API Specification 10A. The following cement types are in standard use for all GSLM operations:

- Class G or Class G cement with 35% silica flour (HTB – High Temperature Blend) may be used with appropriate additives for all jobs other than surface casing jobs.
- Class G or class A cement (whichever is specified in the drilling program) shall be used for surface casing jobs.
- Class A Cement shall be used to cement the conductor.

📖 API Specification 10A, Well Cements, 21st Edition, September 1995.

8.3.2 Additives

Additives and slurry tests shall conform to API Specification 10, Materials and Testing for Well Cements. The various generic additive types used by GSLM are listed below:

- Accelerators.
- Retarders.
- Low density additives (eg Bentonite).
- Friction reducers: dispersants.
- Fluid loss control additives.
- Defoamers and antifoams.
- Gas migration materials.
- Light weight additives (eg Spherelite)
- Lost Circulation Material (Mica etc.)

📖 API Specification 10, Materials and Well Testing, January 1982.

8.3.3 Mixing Water

The table below indicates the maximum contaminant concentration and pH for cement mixing water. Levels above these limits will significantly affect cement additive performance.

Measured Concentration	Allowable Concentration
Cl-	< 7000 ppm
Na, K	< 5000 ppm
Ca	< 500 ppm
Mg	< 300 ppm
Fe	< 300 ppm
Ba	< 300 ppm
SO4-	< 2000 ppm
CO3-	< 100 ppm
HCO3-	< 500 ppm
Dissolved Organics	< 0.02 %
pH	6 - 8

Table 44. Allowable Water Contaminants

8.4 CEMENT SLURRY COMPOSITIONS

8.4.1 Standard Slurries

The following table below give some examples of the types of slurries that may be used in GSLM wells. Actual slurry requirements shall be specified in the Drilling Program and cement program.

Job Type		Cement type / Additives	Est. BHT °F	Slurry Density Lb/gal	Slurry Yield ft^3/sk	Mix Water gal/sx	Unconfined Compress. Strength	Coverage	Excess	Preflush / Spacers	Displace-ment Fluid
Conductor (All wells)		Class A with **1-2%CaCl2**	70	15.8	1.18	5.2		To cellar floor	N/A	N/A	N/A
Surface Casing											
Surface Casing	Lead	Class A or G plus Spherelite and Bentonite		11.0	2.81	13.15	500 psi	To surface	Gauge + 70%	40 bbl fresh water	
	Tail	Class A or G	220	15.8	1.16	5.01	4,000 psi	120 m above shoe	Gauge + 30%		Mud
Intermediate & Production Csg											
Intermediate and Production Casing (BHT < 230°F	Lead	Class G plus bentonite		12.8	2.11	11.78		150 m into previous casing	Gauge + 20% or Caliper + 10%	10 Bbl Dual Spacer, 40 bbl SAPP, 10 Bbl Dual Spacer	
	Tail	Class G	<230 °F	15.8	1.16	5.01	4,000 psi	Min 60m above Hydrocarbons			Interm'd: Mud Prod'n: Brine
Intermediare and Production Casing (BHT > 230°F	Lead	Class G plus bentonite		12.8	2.11	11.78		150 m into previous casing	Gauge + 20% or Caliper + 10%	10 Bbl Dual Spacer 40 bbl SAPP, 10 Bbl Dual Spacer	
	Tail	Class G plus silica flour	>230 °F	15.6	1.56	6.66	4500 psi	Min 60m above Hydrocarbons			Interm'd: Mud Prod'n: Brine

Table 45. Guide to Standard Cement Slurries

8.5 SPACERS

Spacers for cement placement are required to prevent contamination of the cement slurry by the drilling fluid. The table below provides an overview of their formulation.

Displacement	Formulation
High Annular Velocity Slurry Displacements	• A pre-flush brine shall be used prior to cementing the production / intermediate casing / liner. • Spacer will be treated with biocide and will be at a density greater than or equal to mud in the hole prior to cementing. • Spacer volume shall be sized to allow a minimum of 5 minutes contact time with the borehole during displacement and occupy a minimum of 450m of annular volume. • SAPP flush at concentration of 5 kg / bbl shall be mixed with lease water and treated with Biocide at 2 litres / bbl.
Cement Plug Displacement	• A pre-flush brine shall be used prior to cementing. • The spacer density shall be greater than or equal to mud in the hole prior to cementing.
Scavenger Slurry's	• A cement retarder shall be added to the mix water to prevent fast setting of the slurry • Scavenger density shall be between the mud density and the main slurry density. Maximum scavenger slurry density will be 12.0 ppg.
Oil based mud	• No SAPP spacer • Use a specially formulated oil based compatible spacer (normally base oil). • Enable recovery of oil based mud from behind the casing

Table 46. Spacer Formulations.

8.6 SAMPLING AND LABORATORY TESTING

All slurry compositions shall be tested at the Cementing Contractor's laboratory to API Specification 10 and reported to the DM and DSV using an approved contractors form.

📖 API Specification 10, Materials and Well Testing, January 1982.

8.6.1 Sampling Requirements

The following sampling requirements must be adhered to by the Cementing Contractor:

- Samples of the mix water from the current well shall be used.
- Samples of additives shall be taken from the same batch number to be used in the cement job.
- It is essential that the cement sample is representative of the dry cement batch sent to the site, or the cement that will actually be used on the job (site sample).
- Samples of all products, including a 10 litre sample of the mix water, may be taken during the cement job and sent to the Laboratory for post-job testing (if required).
- Samples shall be properly packaged in clean containers supplied by the cementing contractor (do not use cordial bottles etc.) as detailed in the table below. Containers shall be airtight as exposure to humidity could affect test results.
- A water quality check shall be performed by the Drilling Fluids Engineer at the rigsite, immediately before the cement job.

Material	Container
Cement and powdered additives	Airtight plastic bag inside metal can with tightly fitting lid
Mix water and liquid additives	10 litre plastic can supplied by cementing company

Table 47. Sample Packaging.

8.6.2 Sample Quantities

Samples of mix water and other materials shall be provided in the quantities detailed below.

Material	Quantity
Cement	5 kg
Mix water	10 litres
Powdered additives	1 x 300 ml plastic bag (full) per additive
Liquid additives	0.5 litres
Bentonite	1 kg

Table 48. Sample Quantities.

8.6.3 Sample Labels

The following details must be attached to all cement samples:

* Rig name.
* Well name and number.
* Date sample taken.
* Expected date of first cementation.
* Type of cementation planned (e.g. [specify] casing, abandonment plugs, etc.).
* Name of mix water source (e.g. [name] bore, Cooper Creek etc.).
* Where sample was taken from (e.g. Frac. tank, Turkeys nest).

8.7 CEMENT COVERAGE

8.7.1 Annular Coverage of Cement

The cement coverage standards are outlined in the table below.

Cementation	Top of lead	Top of tail	Excess
Conductor casing	Surface	Fill entire annulus with hard, compact cement.	To cellar floor
Surface casing	Surface	Minimum 120m above shoe. A top up job shall always be run.	Lead 70% min excess on gauge hole.Tail 30%excess
Intermediate / Production casing	150m into previous casing shoe	Minimum 120m of tail or to min 60m above top of hydrocarbon bearing reservoirs.	Gauge hole + 20% excess or **Caliper log +10% excess**
Liner	Top of liner lap	Minimum 120m of tail or to min 60m above top of hydrocarbon-bearing reservoirs.	Gauge hole + 20% excess or **Caliper log +10% excess** (lead and tail)

Table 49. Minimum Annular Cement Coverage Standards

Variations to the standards above must be specified in the Drilling Program. These may be required to:

- Prevent buckling of the uncemented section of casing.
- Seal off overpressured water sands.
- Seal off water-bearing sands that are depleted or expected to become depleted in future.
- Cement off all potable water zones.

8.7.2 Corrosion Protection

To prevent corrosion:

1. The fluid in the annular space between casing strings shall be treated with Biocide in accordance with the following guidelines:
   - Biocide shall be added to any fluid left in the annulus.
   - The concentration of Biocide shall be 1,000 ppm (2 litres/ per 10 bbls of fluid).
2. Displacement fluid may contain inhibitor as specified in the drilling program.

8.8 PRIMARY CEMENTING PROCEDURES

The generic procedures given in this Section for cementing casing strings should be used to formulate, verify and check the detailed program.

8.8.1 Conditioning the Hole Prior to Cementing

Prior to cementing, the following steps must be performed to condition the mud and the hole:

- Before running casing, the hole must be circulated clean.
- When breaking circulation with casing on or near bottom, start circulating at low rate and gradually increase rate once returns are established.
- Once casing is on bottom the mud may be conditioned to improve displacement efficiency. This can be done by adding dispersants / thinners to reduce the Yield Point and 10 minute gel strength to minimum practical levels (preferably 2/3). In general YP for 12 1/4" x 9 5/8" to be below 16, for 8 1/2" x 7" to be below 14, for 6 1/8" x 3 1/2" to be below 10.
Do not use SAPP to reduce YP, use lignosulphonate and caustic (or equivalent).
- The mud shall be circulated until gas values are low and stable and the programmed mud rheology obtained.
- Prior to the job circulate a minimum of 120% of the casing contents and continue circulating until the returns are clean to ensure that there is no foreign material in the casing and that the annulus will not pack off with cuttings.
- Annular velocity whilst circulating shall be no greater than whilst drilling.

Notes:

1. Record circulation pressure at the rate that will be used to displace the cement, in order to determine differential pressure and thus estimate the top of cement (TOC).
2. If losses are observed below the rate required to give an annular velocity high enough to meet the displacement requirements, consideration should be given to circulating around a LCM pill. This should be carried out at a rate where slight losses are induced.
3. Cement should be displaced at 95% of the maximum rate achieved without incurring losses.
4. The DSV should calculate the estimated ECD for different circulation rates and determine the likelihood of any potential losses.

8.8.2 Conductor Casing Cementing Procedures (if not pre-set)

The following procedure shall be adhered to during conductor casing cementation:

1. Mix the slurry and pour it into the annular space outside the conductor.
2. Trammel with a pole to ensure the annular space is completely filled with cement.

8.8.3 Surface / Intermediate / Production Casing Cementing Procedures

The following procedure shall be adhered to during surface, intermediate and production casing cementation:

1. For logged Intermediate and Production holes, confirm BHT from logs and compare with programmed BHT, notify DM immediately of any significant difference.
2. Calculate cement volumes. For surface casing use theoretical hole volume + 70% for the lead and hole volume + 30% for the tail (Refer to Drilling Program for required excess). For intermediate and production hole use caliper +10%. If caliper log data not available use a minimum of theoretical hole volume +20% excess.
3. Check mixwater requirement and ensure sufficient supplies are on location. Check quality of mixwater.
4. Hold pre job safety meeting.
5. Rig up cement lines, flush with water and pressure test to 500 psi above burst pressure of casing.
6. Pump spacer (if required).
7. Drop the bottom plug (if programmed).
8. Mix and pump the cement slurry.

   Close valve at cement head and flush lines with water via an upstream Tee.
9. Drop the top plug.
10. Displace the cement slurry. This can be done either using the rig pumps and switching back to cementing contractor for last 5 bbls or by the cementing contractor. Do not exceed 8 bpm during displacement. For displacements carried out by the Cementing Contractor, the displacement tanks shall be used.

    Note: During displacement, monitor the returns closely to ensure there are no losses. If unacceptable losses are encountered, reduce the pump rate in increments of ¼ barrel per minute until returns are regained.
11. For the last 5 - 10% of displacement volume before bumping the plug, slow the pumps down to 1/4 - ½ of displacement rate and record this pressure. This final displacement pressure shall be used for calculating the estimated TOC. Record final displacement pressure on casing/cement report.
12. Bump plug and record bump pressure. For all surface and intermediate casing jobs pump a maximum of the theoretical displacement plus half the volume of the shoe track. On production casing displacements pump until the plug bumps.
13. If the plug bumps pressure test the casing to the pressure specified in the Drilling Program (usually 500 psi above bump pressure).
14. Casing pressure tests must not exceed 80% of the burst pressure of the casing or the rating of the wiper plug. Hold pressure for 10 minutes.
15. Release pressure, measure and record backflow. If, on surface and intermediate casing, there is flow back - do not pump any volume of mud back as there is the possibility of pumping mud contaminated cement around the shoe.
16. When cementing surface casing, a top cement job shall always be carried (unless otherwise specified in the program) out to ensure cement is at surface. This should be done with a 1" cement stinger using tail cement with 1-3% $CaCl2$.

8.8.4 Liner Cementing Procedures

8.8.4.1 Pre-cementing job checks:

1. Check on cement lab test results. Utilise a low fluid loss, low viscosity, non-settling slurry.
2. Confirm BHT from logs and compare with programmed BHT, notify DM immediately of any significant difference.
3. Check mixwater required and ensure sufficient supplies are on location.
   Check quality of mixwater.
4. Determine cement volumes based on caliper logs (caliper volume +10%).
5. Check liner and cementing equipment and materials, i.e. hanger, running tools, cement head, float equipment, safety equipment, cement, additives, preflush chemicals, etc.
6. Centralise liner to achieve 70+% stand-off. One centraliser per joint through production zones is recommended.
7. Confirm maximum safe pump rates for circulating mud, pumping slurry, and displacing in order to achieve maximum cement placement efficiency without fracturing the formation. Ensure that cementer is aware of pump rates and pressures to be used.
8. Cement mix water (the same as was used to do the lab tests) is to be kept in thoroughly clean tanks or pits.
9. Calculate volumes of displacements to liner wiper plug at top of liner and to landing collar.
10. Hold safety meeting.
11. Rig up cementing equipment. Aerate the bulk cement well and ensure bulk systems are functioning properly.
12. Perform Surface Line Friction Test at 6 and 8 BPM and record, i.e. pump through open-ended lines and hose (not through Lo-Torc valve) on to rig floor.
13. Condition hole during circulation, reciprocate pipe very slowly and circulate at slowly increasing rates until maximum safe rate has been achieved. This should be after a minimum of 3 hole volumes have been pumped, or pump pressure and mud rheology have stabilised and measurement of returns indicates near 100% wellbore displacement efficiency. Record pressures at the different rates.
14. Set Liner hanger.

8.8.4.2 Cementing:

1. Flush lines and pressure test with water to 1000 psi above maximum expected pressure.
2. Mix and pump flushes at maximum safe rate, minimising surging effect on the hole.
3. Monitor and record return volumes throughout cementing operation.
4. Mix and pump cement slurry at required density, confirming density with a pressurised balance (if available). Pump at maximum safe rate.
5. Record all mixing and pumping rates, volumes and times accurately.
6. Drop pump down plug.

7. Pump displacement at maximum safe rate. Slow pump rate just prior to the pump down plug reaching the liner, noting the volume and amount of pressure increase when the pump down plug shears the liner wiper plug. Re-calculate or correct remaining displacement volume if necessary.
8. Resume pumping at maximum safe rate if possible.
9. Bump plug. If liner is to be drilled out do not pump more than theoretical displacement + 50% of shoe track volume.
10. Pressure test liner to 60% of liner burst pressure, or hanger pressure rating, whichever is lower. The actual pressure will be specified in the drilling programme.
11. Release pressure, measure returns and check for float valve functioning.
12. Set liner packer if applicable. Release setting tool.
13. Circulate out excess cement slurry, DO NOT reverse if a liner top packer has not been set.
14. When cement samples have set pressure test liner top to pressure specified in programme.

8.8.5 Stage Cementing

The procedure below applies to the use of a stage cementing collar with a free-fall opening plug that is the preferred method except in deviated wells when continuous cementing is required.

1. Rig up cement lines and flush lines with water and pressure test to 1,000 psi above expected maximum pressure.
2. Carry out circulation test, record rates and pressures. Pump preflush.
3. Drop bottom plug (if applicable). Pre-mix and re-circulate slurry until gradient is within safe tolerance.
4. Mix and pump cement.
5. Drop the 1st stage top plug.
6. Displace at pre-determined maximum loss free rate using the cementing pumps (Rig pumps as backup). Before theoretical bumping of the plug, reduce the rate to ¼ to ½ of full displacement rate. Record pressures at these rates.
7. Bump plug and record bump pressure. Pump a maximum of the theoretical displacement plus half the volume of the shoe track.
8. Release pressure and check for backflow.
9. If backflow is observed, shut the well in, wait for 30 minutes and check again. If backflow continues, shut in well and WOC.
10. Release free-fall stage cementing collar opening plug and wait (approximately 5 1/2 minutes/1000 m for the plug to seat.
11. Increase pressure to open multi-stage cementing collar as per manufacturer's instructions. If plug fails to open, release pressure and wait for another 5-10 minutes.
12. Establish circulation and circulate minimum of 120% of annular contents. Check for spacer-cement returns from 1st stage and for losses.
13. Switch over to the cement line, pressure test line.
14. Pump preflush

15. Pre-mix and re-circulate slurry until gradient is within safe tolerance
16. Mix and pump cement.
17. Drop the stage cementing collar closing plug.
18. Displace at maximum rate using the cementing pumps. During displacement, monitor the pressure; if it is low, continue displacing with the cementing pumps but monitor the returns closely to ensure there are no losses. Before theoretical bumping of the plug reduce the pump rate to approximately ¼ to ½ of full displacement rate

    Note: Pressure surges must be minimised by breaking circulation carefully, particularly on opening the stage cementing collar, to avoid weakening or shearing closing sleeve shear pins.

19. Bump plug into the multiple stage collar. Hold pressure for 5 minutes. Release pressure and pressure test casing to pressure specified in drilling programme for 10 minutes. Release pressure and check for back-flow. In case of back-flow, close in the well and wait on cement.

8.8.6 Reporting

The DSV, Toolpusher and Cement Contractor Supervisor shall complete a Pre Job Checklist prior to commencing the cement job

The DSV shall complete the Casing and Cementing Report.

8.9 SQUEEZE CEMENTATION

Squeeze cementing operations are required as follows:

- To abandon specific reservoirs in a multiple reservoir completed well.
- To seal off all perforations when abandoning a well to prevent crossflow between reservoirs.
- To repair defective casing or liner cement jobs.
- To plug a severe lost circulation zone.
- To repair casing leaks.

8.9.1 Methods

Squeeze cementing consists of applying surface pressure to force a cement slurry into the annular space between the casing and the formation, into other areas of the well, or into the formation. The following methods may be used in performing a squeeze cementation:

- **A high pressure squeeze.** This is where the slurry is placed using sufficient pressure to fracture the formation. Whole cement slurry is placed into the formation fractures.
- **A low pressure, or hesitation squeeze.** This is where the cement slurry is placed with hydraulic pressure below the fracture pressure of the formation. For example, in a "spot and squeeze" (also called a "block squeeze"), cement is spotted over the required interval, before hydraulic pressure is applied. Hydraulic pressure is then applied in order to force or squeeze the cement filtrate in the pore space of the formation, or the perforations leaving a filter cake of cement solids coating the formation and filling the perforations. In order to build this filter cake, pumping must stop periodically, or hesitate, to allow time for the filtrate to seep into formation pore space and reduce hydraulic pressure.
- **A circulation squeeze:** This should be used when there is not enough cement behind the casing string, or the cement is shown to be poorly bonded in places where it is required for zonal isolation. The casing is perforated in two places, a packer is set between the perforations and cement is circulated through the annular space between casing and the formation.

8.9.2 Guideline

The following squeeze cementation guidelines should be adhered to:

- If an attempt is planned to squeeze cement into perforations or into a casing leak, injection rates must be established before cement is squeezed.
- High squeeze pressures which may induce formation breakdown should be avoided in order to prevent zonal communication via vertical fissures.
- When a packer has been set just above the perforations or zone to be squeezed off, the bottom hole pressure must be kept below 80% of the burst pressure of the weakest casing used. Changing the setting point of the packer or applying back pressure may increase the allowable squeeze pressure. Annular back pressure should be applied in all cases having a differential pressure across the packer greater than 1,500 psi.
- The hesitation squeeze technique should be used in lost circulation zones to aid bridging of the cement solids. This involves squeezing, waiting a few minutes, and squeezing again until no further injection is possible or all cement is used.
- The hesitation squeeze technique is not recommended across perforations, as there is a risk that cement will bridge-off prematurely, and fail to seal the perforations permanently.

- The simplest way to carry out a squeeze is to spot the cement and squeeze it by applying pressure while the annulus is kept closed (bradenhead or poorboy squeeze). Balanced cement plugs are described in Section 8.10.2. A packer must be used if the pressure during the squeeze will exceed the maximum allowable pressure at any point above the planned depth of the cementation.
- If no packer is used, a weighted high viscosity pill of approximately 45 m (150 ft) length should be used as a bottom to retain the cement.
- If there are any perforations below that require to be protected from the squeeze pressure and/or cement that might work its way down the hole, a bridge plug must be set approximately 4.5 m (15 ft) below the interval to be squeezed off.

8.9.3 Squeeze Cementing Procedures

High and low pressure cementation procedures are described below.

8.9.3.1 Spot and Squeeze Cementing Procedure (Low Pressure)

1. RIH with cementing stinger and spot a weighted high-vis pill.
2. Set a balanced cement plug.
3. Pull back immediately but carefully to approximately three stands (approx. 90 m {300'}) above the theoretical TOC and direct circulate bottoms up.
4. Close the annular BOP.
5. Squeeze away the cement at a constant pressure not exceeding the formation fracture pressure.
6. Squeeze 50% of the available slurry and commence a (hesitation) squeeze.
7. Hesitate and pump in steps of 1 to 10 minutes until the required amount of cement is displaced or injection stops. A minimum 9 m (30') of cement must be left above the zone.
8. POOH with the stinger. Circulate to remove cement from inside pipe.

8.9.3.2 Squeezing Through a Cement Retainer (High Pressure)

1. Set a drillable cement retainer on drill pipe approximately 9 m (30') above the perforations to be squeezed.
2. RIH with cement stinger on drill pipe and tag retainer. Establish circulation, stab into retainer and perform injection test. Check stinger can be properly stabbed into retainer. Pull out of retainer 1 m (3').
3. Pump the spacer and cement, displace until the spacer reaches the end of the stinger. Back pressure should be applied on the annulus to balance the cement column.
4. Stab into the cement retainer.
5. Squeeze away the cement or until injection stops. Do not hesitate squeeze.
6. Pull out of the cement retainer and pull up 1 stand, reverse circulate clean and POOH.

8.9.3.3 Circulation Squeeze

1. Perforate the casing at the top and bottom of the repair interval.
2. Set a drillable bridge plug or retainer on drill pipe between the perforations.

3. RIH with cement stinger on drill pipe, stab into the bridge plug and establish circulation.
4. Circulate a solids-free fluid at increasing rates until the pressure at the perforations equals the leak-off pressure.

Notes: If circulation cannot be established, the job should not continue. DM shall be consulted who shall advise the next course of action.

5. Pull out of the bridge plug, and pick up 2 m. Pump spacer followed by the cement slurry to a level 10m above the bridge plug.
   Back pressure should be applied on the annulus to balance the cement column.
6. Stab back into the bridge plug and displace cement.
7. Pull out 27m above the top perforations and reverse circulate drill pipe clean. POOH..

8.10 PLUG CEMENTATION

Cement plugs are placed in the wellbore for the following reasons:

- To cure lost circulation while drilling.
- To sidetrack an existing wellbore.
- To abandon a depleted zone.
- To abandon a well.

8.10.1 Guidelines

The following general guidelines shall be adhered to during plug cementation:

- In general cement plugs should not exceed 100 m in length. If the hole is badly washed out, it may be better to set 2 short plugs over the washed out section.

- For open hole plug backs, any caliper information available should be used to calculate the slurry volume (+10% excess). If no caliper is available 20% above theoretical volume should be used.

- The TOC should be calculated to be 15 m above the minimum required top.

8.10.2 Setting a Balanced Plug Procedure

When setting a balanced plug, the following procedure shall be followed:

1. RIH with a tubing stinger, at least the length of the plug, on drill pipe to 60 m (200ft) below the planned depth of the bottom of the plug.
2. Circulate 120% of the cementing string contents before setting the cement plug. The mud must have a constant weight before pumping the cement.
3. Spot a minimum of 60 m of viscous mud pill below plugs setting depth.
4. Pull up to setting depth.
5. Pump the spacer and the cement. The slurry should be batch mixed, When this is not possible the slurry must be re-circulated untill a consistent weight is achieved.
6. Pump the required volume of spacer after the cement to balance plug.
7. Under-displace with mud, according to the program, to avoid backflow.
8. Do not rotate string in cement plug.
9. Pull back immediately and slowly to approximately 30 m above TOC and direct circulate bottoms up. Do not reverse circulate above plugs set in open hole.
10. If the plug has to be tagged after the cement has hardened, keep moving the stinger while WOC.
11. Set the next plug or POOH.

8.11 CEMENT EVALUATION

Cement evaluation techniques which may be applied are described below

8.11.1 Temperature Survey

A temperature survey can be used to indicate both the presence of cement and TOC during setting as the chemical reaction gives off heat. The amount of heat depends on well conditions and slurry design. Temperature surveys cannot be used for qualitative evaluation of the cement job because no indication of bonding is given.
For this reason temperature surveys are rarely run.

- The temperature survey can be used to determine TOC where a cement evaluation log (CBL, CBL/VDL, CET etc.) is not planned or may be unreliable due to size of casing.
- Optimum time to run a temperature survey is between 6 – 12 hours after cementation.
- For best results, the fluid inside the casing must be left undisturbed following completion of cementation until the survey is made
- The log should be recorded while running in the hole.

8.11.1.1 Interpretation

The temperature survey log should follow the formation temperature gradient until a step increase in temperature indicates TOC. Below the TOC the temperature is dependant upon the mass of cement in the annulus. The greater the mass of cement the greater the temperature. Consequently, the log should correlate with the caliper (if run). Lack of correlation is probably an indication of channeling. Temperature anomalies can also be related to poor zonal isolation and resulting fluid movement behind casing.

8.11.2 Cement Evaluation Logs

Electricline (sonic) logs may be run to evaluate casing cementations. These logs require cement to have set and hardened for several days before the logs can give reliable indication of cement bonding and isolation quality. For this reason, such logs are generally not run as part of the drilling operations, and are more commonly carried out as part of a subsequent well completion.

8.12 QUALITY CONTROL AND DOCUMENTATION

This Section defines reports prepared during and after cement jobs..

8.12.1 Contractor Reports

The Cementing Contractor shall provide a field report to the DS not later than 24 hours following the completion of any cement job. The required contents of this report are tabulated below.

Topic	Required Information
Cement	• Class of cement and amount used • Cost of cement
Additives	• Names of additives and amounts used • Cost
Spacer	• Composition • Cost
Cement Placement	• Estimated TOC
Volume Requirements	• Spacers • Slurries • Displacement water
Operations Information	• General (e.g. pipe reciprocation) • Cement wiper plugs • Displacement rate and pump efficiency • Plug bump volume, over-displacement
Pressure Chart	• Description of all operations marked on chart • Start and stop times • Pressure test of casing
Drilling Fluid Data	• Type • Weight • Rheology and gels
Centralisation	• Type, depths and spacing
Cementer's Comments	• General comment on the performance of the cementing procedures and programme together with recommendations for future wells

Table 50. Cementing Contractor Reporting Requirements.

8.12.2 GSLM's Reports

The DSV shall compile the reports as listed in the table below.

- Casing and cementing report
- Abandonment report

Secondary and remedial cementation do not require a specific reporting format. Data pertaining to the cement plug or squeeze should be detailed on the Abandonment Cement Plug Report.