Working Report 2005-27

Results of Monitoring at Olkiluoto in 2004

Foreign Materials

Piia Juhola

June 2005

POSIVA OY
FI-27160 OLKILUOTO, FINLAND
Tel +358-2-8372 31
Fax +358-2-8372 3709

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ABSTRACT

This report focuses on materials introduced to ONKALO, which are not part of the multi-barrier system or the natural environment. All the materials, both allowed and forbidden, introduced to ONKALO are listed in the material handbook. All materials used in ONKALO in 2004 are listed in this report, and the report also includes a comparison of their amounts against the estimated amounts. Part of the foreign materials will be removed with ventilation air, drainage water or during the cleaning process.

Keywords: foreign materials, disposal of spent fuel, monitoring, Olkiluoto, ONKALO

TIIVISTELMÄ

Tässä raportissa käsitellään ONKALOon vuoden 2004 aikana kuljetettuja materiaaleja, jotka eivät liity moniesteperiaatteeseen tai kallioperään. Kaikki ONKALOn rakentamisen aikaiset sallitut ja kielletyt materiaalit on listattu materiaalikäsikirjassa. Raportissa on kerrottu kaikki vuonna 2004 ONKALOon viedyt materiaalit ja verrattu näitä etukäteen ennakoituihin arvoihin. Osa näistä vieraista materiaaleista poistuu ONKALOsta ilmanvaihtojärjestelmän, kuivatusveden tai puhdistuksen myötä.

Avainsanat: vieraat materiaalit, käytetyn ydinpolttoaineen loppusijoitus, monitorointi, Olkiluoto, ONKALO

TABLE OF CONTENT

1 INTRODUCTION

According to plan, in Finland spent nuclear fuel will be disposed of in a KBS-3 repository at a depth of about 500 meters in the bedrock of Olkiluoto. Excavation works for ONKALO started in august 2004 and the construction of ONKALO is scheduled to be completed by the end of 2010. The underground parts of ONKALO consist of a system of exploratory tunnels accessed via a tunnel and two shafts, a ventilation shaft and a transport shaft. It has been assumed that in the future ONKALO will be part of the spent nuclear fuel repository (Vieno et al 2003). At the end of 2004 ONKALO's access tunnel was situated at chainage 155. Each tunnel chainage is one metre long. The mined volume of ONKALO was 6250 m^3.

Foreign materials (or engineered and stray materials) in ONKALO are introduced materials that are not part of the engineered barriers, rock material or groundwater. Part of these foreign materials will be removed in different cleaning processes, but some will remain in the future repository (Hjerpe 2003).

Foreign materials remaining in ONKALO mostly consist of the cement used for grouting and for shotcreting to stabilise the ceilings and the walls of the excavation (Vieno et al 2003). The estimated amount of grouting and shotcrete cement introduced in ONKALO is about 5300 tons. Another potentially harmful group of foreign materials consists of hydrocarbons, urine, nitrogen compounds from explosive residues and organic materials. The majority of the organic materials is estimated to originate from the ventilation air, other major sources of organic materials that will remain in ONKALO include cement additives, superplasticisers. Superplasticiser are used to improve the workability of shotcrete and grouting cement (Posiva 2003a).

Foreign materials used in ONKALO are monitored and controlled as part of long-term safety. The amounts and types of chemicals to be taken into ONKALO will be restricted, in so far as they are needed at all. The amount of toxic and explosive substances will be minimised (Posiva 2003b). Some instructions are available as to the selection of materials for use in ONKALO taking into consideration the salinity and sulphide level. Because of these factors, acid proof steel and other corrosion proof materials should be used. Most of the construction materials will also be incombustible.

As all materials are not computable, the amounts of these are based on an estimate. These materials include, for example, rubber from tyres, exhaust fumes from diesel engines (soot, ash and nitrogen oxide), hydraulic and lubricants oils, urine and other miscellaneous human waste. The amounts of these materials are not estimated in this report, but are available in Hjerpe 2003 and Vieno et al 2003.

Disturbances can be experienced in the surrounding rock and groundwater environments during the construction project and the operating period of ONKALO. Various substances may be dissolved from foreign materials , which can eventually migrate to the disposal level. During the construction project ONKALO acts as a swallow hole with groundwater flowing towards the development area. Foreign materials that remain

in ONKALO at filling time will have direct contact with processes that affect the buffer bentonite, the canisters or the rock.

Foreign materials can contain detrimental constituents that may have a negative effect on engineered or natural barriers in the repository. For example, they can affect the buffer bentonite and the migration of radionuclides. High pH-plume from cement affects the buffer bentonite negatively and can also affect the spent fuel. Organic materials, such as oils can influence the migration of radionuclides through the buffer bentonite and the near-field rock. Sulphides and nitrogen compounds can cause corrosion of the canisters (Vieno et al. 2003). High amounts of introduced potassium compounds and phosphorous compounds should also be avoided. High levels of potassium might be detrimental to bentonite due to possible illitization of bentonite. Phosphate is a potential strong complex former for actinides and may thus affect the migration of actinides.

2 MATERIAL HANDBOOK AND QUALITY ASSURANCE

2.1 Material handbook

The material handbook is a list of materials allowed in ONKALO. It includes separate directions for all materials, safety data sheets and other information of the materials. All the materials used in ONKALO have been divided into two safety classes, the highest safety class A and safety class B. Materials in safety class could influence the long-term safety. Materials in safety class B have no detrimental influence on long-term safety according to present knowledge. The highest safety class A includes cement, concrete and additives; organic compounds; inorganic nitrogen compounds and other inorganic compounds. Safety class B includes metals and other materials. Only materials listed in the material handbook are allowed for use in ONKALO. Everyone working in ONKALO is obliged to check that the material needed are included in the material handbook and in the list of allowed materials.

The material handbook is in Finish but some of the safety data sheets and information sheets can be in Swedish or in English. The handbook is available as a nine-page hard copy and in electronical form in Posiva's Kronodoc-system. The material handbook will be updated as needed.

2.2 Allowed foreign materials

At the end of 2004 the material handbook listed 35 allowed materials, 30 in safety class A and 5 in safety class B. Some restrictions apply to the use of the materials; for example, materials may only be used for the purpose they are designed, i.e. motor oils may only be used in vehicles. All the allowed materials are presented in Table 1.

2.3 Forbidden foreign materials

At the end of 2004 the material handbook listed 16 forbidden materials. All the forbidden materials are presented in Table 2. These materials have been forbidden as new materials better in terms of long-term safety have been found or because the material is not suitable to ONKALO conditions.

2.4 Introduction of new material in ONKALO

The material handbook includes instructions for the introduction of a new material or substance in ONKALO. The basic information required for a new material or substance includes the safety data sheet, the components of the material, the name of the producer and the supplier, the purpose of use and the planned use in ONKALO as well as a possible sample of the material. Some laboratory experiment or test may also be required of the materials. The acceptance procedure may take a long time, up to a year.

A new material can be allowed for use in ONKALO and added in the list of allowed materials in the material handbook provided it is not harmful to long-term safety. The material must also be suitable to ONKALO conditions and its functionality must have been tested. For materials included in safety class A the disadvantages of its use must be smaller than the disadvantages of it not being used.

2.5 Quality assurance

Posiva Oy's operational system covers all the functions in the company. Quality assurance procedures have been established for all functions in safety class A and B. The use of foreign materials in ONKALO is part of the quality assurance program for ONKALO with separate quality instructions provided for it (Juhola 2005). The quality assurance instructions concerning foreign materials include instruction for research, development and building activities. Certain competence requirements have been defined for people who use or accept foreign materials, as well as instructions for control and documentation. The acceptance limits for the use of foreign materials have also been defined. The acceptance limits have initially been calculated in the report Hjerpe 2003. Instructions have been provided for cases where the limits are exceeded, and for the application of the CEIC procedure (Vira and Sievänen 2005).

2.5.1 Decision and change management during construction of ONKALO for issues of relevance to long-term safety, CEIC

Posiva has adopted the CEIC procedure (Vira and Sievänen 2005). The CEIC procedure is required to identify the risks involved in the construction process and to determine the trigger levels for migration actions. The CEIC procedure is also required to identify and suggest possible modifications in the construction process when needed, to create procedures for change management, and to ensure compliance with requirements. For foreign materials, the CEIC procedure is used when introducing a new material to ONKALO, when using materials within the limits and outside the limits. The acceptability of the qualities and quantities of foreign materials to be used in ONKALO is also included in the CEIC procedure.

Table 1. *Allowed materials in ONKALO 2004 by safety classes and subgroups.*

HIGHEST SAFETY CLASS A			
Cement, concrete and additives	**Organic compounds**	**Inorganic nitrogen compounds**	**Other inorganic compounds**
Cementa Set Control II	AT-marking paint	Anite	Falu Red Ochre Paint
Scancem SP-40	GlykoShell	Firex VA-T	
Grout Aid	Lasol 100	F-17 x 460 pipecharge	
Ultrafin 16	Nuto H32	Kemix A-pipecharge	
SR-cement	Shell Grease Centra W	F-cord 10 detonating cord	
Mapequick AF-2000	Shell Spirax AX	Riocord	
Super-Parmix	Shell Helix Ultra Motor Oil 5W-40	Nonel detonators	
	Donax YB brake fluid	Fordyn Dynamite	
	Shell Universal Engine Oil	Kemix A cartridge	
	Shell Rimula X Oil 10W-30		
	Shell Retinax Grease HDX2		
	Shell Form 5		
	Shell Tellus Oil		

SAFETY CLASS B	
Metals	**Other**
CT-rock bolt	Absodan Universal
Deformed reinforcement bar	Peel Off China Marker
Shotcrete fibres CF 03-35	

Table 2. *Materials forbidden for use in ONKALO.*

Name of the material	**Reason for rejection**
Perus-Parmix	Includes lignosulphate
Rescon Mapei SPRUT 34	Better alternative found
Masterbuilders Rheocem 800T	Better alternative found
Masterbuilders Rheocem 800SR	Better alternative found
Masterbuilders Rheobuild 2000PF	Better alternative found
Mikrocem 800	Better alternative found
Mikrocem 650 SR	Better alternative found
Mapefluid 400N	Better alternative found
Windscreen washing agents	Only Lasol allowed
Würth marking paint	Better alternative found
Master marking paint AQUA	Better alternative found
Marking paint Mercalin RS	Better alternative found
Oil based red paint Tikkurila	Better alternative found
Siroplast 2 roofpaint, Tikkurila	Better alternative found
VB-Parmix	Includes polycarboxylat
Hilti HIT-HY 150	Forbidden in ONKALO design plan

3 USED MATERIALS AND AMOUNTS IN ONKALO 2004

Hjerpe (2003) has estimated the quantities of foreign materials remaining in the different parts of ONKALO at the time of the final backfilling of the repository. These materials are listed in Table 3. Table 3 also shows the estimated amount of the materials per each excavated cubic meter. Materials are not used linearly in the tunnel. Prior to the backfilling of the repository, as much as possible of foreign materials that are not needed for stability and safety purposes during the backfilling and sealing operations will be removed (Vieno et al 2003). Table 4 lists the materials in ONKALO in 2004 and their amounts.

The categorization of the materials is similar to the one used in the material handbook. Cement, concrete and additives are actually mostly organic compounds but here they are discussed separately.

3.1 Safety class A

3.1.1 Cement, concrete and additives

In the open cut Cementa Ultrafin 16 was used as a grouting cement. The additives of the cement, i.e. the superplasticiser was Cementa Set Control II or Scancem SP-40. The plugging cement used in the open cut was Rapid.

In the tunnel Cementa Ultrafin 16 was used as a grouting cement. Cement additives were also used, either Cementa Set Control II or Scancem SP-40 with Grout Aid.

A summary of the cement materials used in the tunnel is provided in Appendix 1. The amounts of concrete and cement additives per chainage meter are shown in graphical form. The amounts and volumes are given from the starting chainage of the grouting. The injection boreholes are about 22 metres long, so grouting materials spread out accurately.

The estimated amount of grouting cement was 2500000 kg for all of the ONKALO access tunnels (0 to -520 m). At chainage 155 111553 kg of grouting cement has been used, which is 1,6 times more than estimated. More grouting materials are needed at the beginning of the ONKALO tunnel.

At chainage 29 grouting additive Scancem SP-40 with Grout Aid was tested. The combination did not work properly and SP-40 has not been used since.

3.1.2 Organic compounds

Measurement points were marked in ONKALO with AT-marking paint. Different kinds of organic oils, such as lubricants and anti-freeze solutions were used in the vehicles in ONKALO. The amounts of these and the amounts that probably stayed in ONKALO

have not been calculated or estimated in this report. The names of all the organic compounds and materials used are provided in the material handbook and in Table 1.

3.1.3 Inorganic nitrogen compounds

Inorganic nitrogen compounds are mainly explosives. In the open cut Fordyn dynamite, Anite or Kemix-A were used as explosive agents. NONEL detonators were used as blasting caps. The cartridge wire was Riocord 100 g/m.

Explosives manufactured by Forcit Oy were used in the tunnel. The explosive agents included Anite, F-pipe charge (F 17 x 460) and Kemix-A. Kemix-A is a pipe charge (size 32 – 36 x 1000) or a cartridge (size 36 x 530). NONEL LP detonators were used as blasting caps and F-cord 10 as detonating cord.

A summary of the explosive materials used in the tunnel is provided in Appendix 2. The amounts of explosives per chainage meter are given in graphical form.

At chainage 62 more explosives (Kemix-A pipecharge, NONEL detonators and F-cord 10) have been used than in other places. This was due to the correction blasting of the tunnel.

3.1.4 Other inorganic compounds

No inorganic compounds other than those listed in 3.1.3 were used in ONKALO in 2004. only one other allowed inorganic compound is listed in the material handbook.

3.2 Safety class B

3.2.1 Metals

Support bolts were used for rock reinforcement. Hot-dip galvanized bent reinforcement bars A500HW were used at the tunnel face and in the open cut. Sormat PFG M10 metal fastening hooks have been used in the tunnel. The measurement points were marked with 150 x 28 mm brass sleeves.

***Table 3**. The estimated quantities of engineering and stray materials in ONKALO at the time of backfilling, listed by origin. Hjerpe 2003. 1) kg/m drainage pipe, 2) at the time of backfilling.*

	Origin of the stray material	**Chemical content**	**Estimated quantities(kg)**	**Removal efficiency %**	**Remaining quantity(kg)**	**Estimated kg/m^3**
1	Gas from explosives	Nitrogen oxide	2500	99	25	7,5 g
2	Blasting caps and cords	Polyethylene(PE)	1500	90	152	
		Aluminium	660	90	66	
3	Support bolts	Steel	350000	0	350000	
		Cement	58000	0	58000	350
		Zinc	7000	0	7000	
4	Anchor bolts	Steel	20000	40	12000	
		Cement	2600	0	2600	350
5	Shotcrete with admixtures	Cement	2232000	0	2232000	400
		Aluminium	89000	0	89000	16
		Steel	26000	0	26000	60
		Zinc	3500	0	3500	8
6	Injection material	Cement	3000000	0	3000000	
		Organic materials	90000	0	90000	
7	Floors	Cement	1750000	98	35000	300
		Steel	210000	99	2100	5,25
8	Miscellaneous structures	Cement	1900000	98	38000	300
		Aluminium	75000	98	1500	
		Steel	28500	98	570	60
		Zinc	1100	98	22	8
9	Drainage pipes	Steel	2400	0	2400	0,300(1
		Polyethylene (PE)	1400	0	1400	0,181(1
		polystyrene(EPS)	550	0	550	0,070(1
10	Wear from tyres	Rubber	60000	90	6000	1,064 kg/m(2
11	Exhaust fumes from diesel engines	Nitrogen oxide	540000	99	5400	0,957 kg/m(2
		Shoot and ash	31428,5	93	2200	0,383 kg/m(2
12	Diesel oil	Hydrocarbons	86000	95	4300	0,019 (2
13	Battery acid	Sulphuric acid	1200	90	120	0,021 kg/m(2
14	Hydraulic and lubricating oils	Hydrocarbons	18000	90	1800	0,004(2
15	Degreasing agents and detergents	Hydrocarbons and organic materials	28000	95	1400	0,004(2
16	Hard metal and metal fragments	Steel	125000	98	2500	0,005(2
		Tungsten and Cobalt	950	98	19	$5{,}6 \cdot 10^{-4}$ (2
17	Urine	Carbamide (incl. H_2O)	460000	95	23000	0,10 (2
18	Miscellaneous human waste	Organic materials	290000	98	5800	0,0026(2
19	Ventilation air	Organic materials	6060000	95	30300	

Table 4. *All materials used in ONKALO, names and amounts in 2004.*

ONKALO 2004			*Used / m^3*	*Used / tunnel m*	*Estimated*	*Estimated/m^3*
			6250 m^3	155 m		228318,1
CEMENT, CONCRETE AND ADDITIVES						
open cut	Cementa Ultrafin 16	15359 kg				
	Cementa Set Control II	197,7 kg				
	Scancem SP-40	65,6 kg				
	Rapid-cement	7122 kg				
tunnel face	shotcrete Cem I 42,5 M	3 m^3				
tunnel	Scancem SP-40	401,9 kg	0,064	2,6		
	Cementa Set Control II	1671,3 kg	0,267	10,8		
	GroutAid SG	2232,5 kg	0,36	14,4		
	Cementa Ultrafin 16	111553 kg	17,85	719,7	2500000 kg	10,95
ORGANIG COMPOUNDS						
tunnel	AT-marking paint	86,8 l		0,56		
INORGANIC NITROGEN PRODUCTS						
excavation road	Detonators	212 kpl				
	Dynamite	56,7 kg				
	Anite	76,6 kg				
open cut	Detonators	529 kpl				
	Dynamite	687,2 kg				
	Anite	1250,7 kg				
	RT cord	1626 m				
	Selkälanka	215 m				
	Kemix-A	16 kg				
	F pipe charge	1 kg				
tunnel	NONEL detonators	4405 kpl	0,71	28,42		
	RT cord	6103 m	0,98	39,37		
	Anite	674 kg	0,11	4,35		
	Kemix-A cartridge	740 kg	0,12	4,77		
	Kemix-A pipe charge	15219 kg	2,44	98,19		
	F pipe charge (F 17 x 460)	1385 kg	0,22	8,94		
	Explosives total	18018 kg	2,89	116,25		
METALS						
open cut	A500HW kzn 25*3000	60 kpl				
	A500HW kzn 25*4000	39 kpl				
tunnel face	A500HW kzn 25*4000					
	A500HW kzn 32*6000	8 kpl				
tunnel	Sormat PFG M10 wedge anchor	200 kpl				
	Brass sleeve 150 x 28 mm (03kg/each)	3 kpl				

4 DISCUSSION

In 2004 the most important objective with respect to foreign materials was to find materials suitable for use in ONKALO and for long-term safety of nuclear waste disposal. These materials have been categorized and the materials that are allowed in ONKALO have been listed. The material handbook has been compiled for this reason. In 2004 the material handbook listed 35 allowed materials organized in different categories. 16 materials were proposed in 2004 that were not allowed for use in ONKALO. These materials have been replaced with other material better for long-term safety.

The main foreign materials in ONKALO have included cement with various additives, and explosives. More cement has been used at the beginning of ONKALO per tunnel chainage than had been estimated. The amounts of explosives corresponded to estimates.

5 REFERENCES

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APPENDIX 1

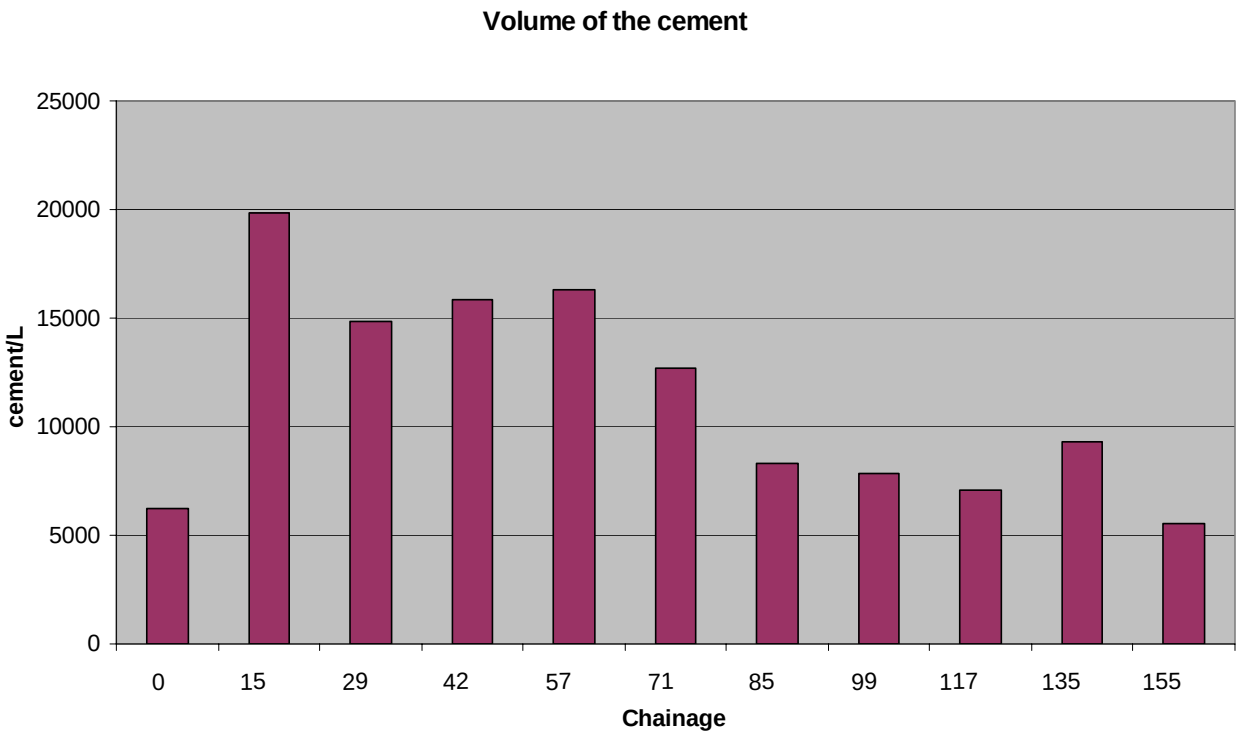

Figure 1. *Volume of the UF-16 cement used for grouting in ONKALO.*

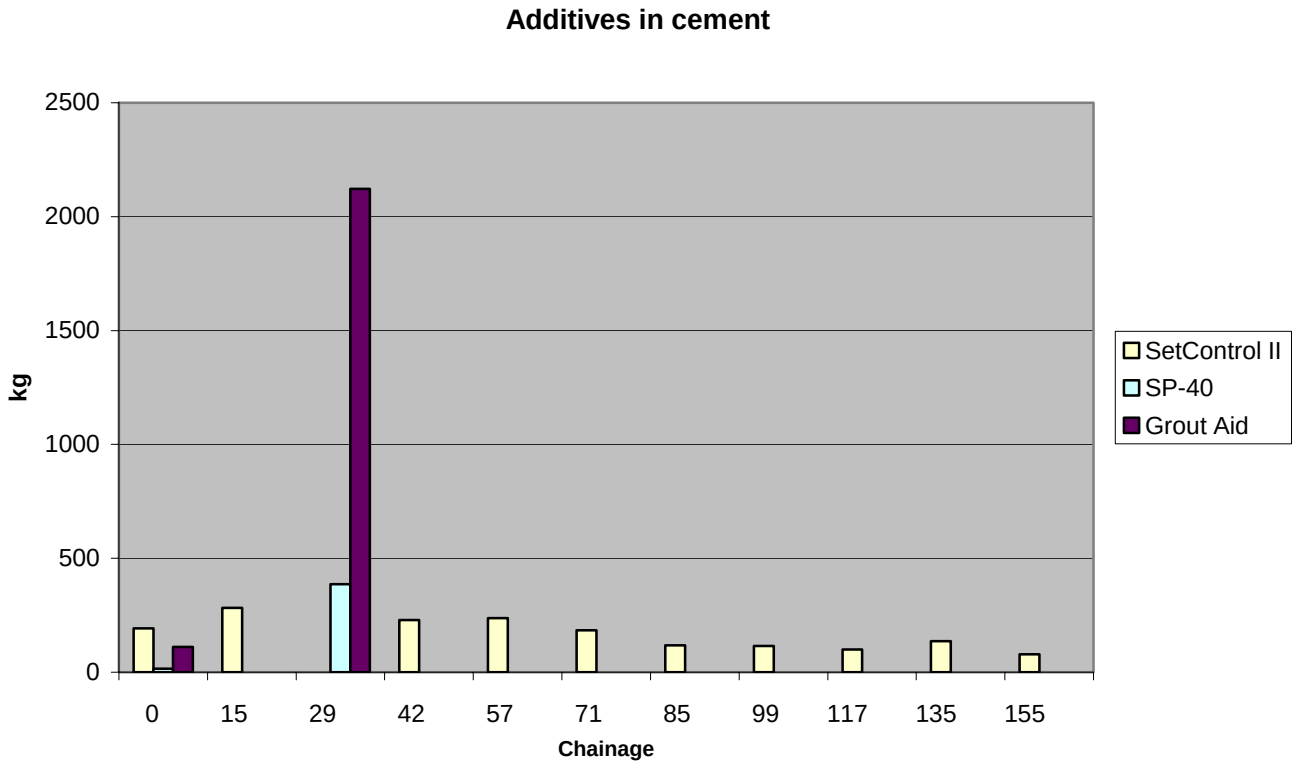

Figure 2. *Additives in grouting cement used in ONKALO.*

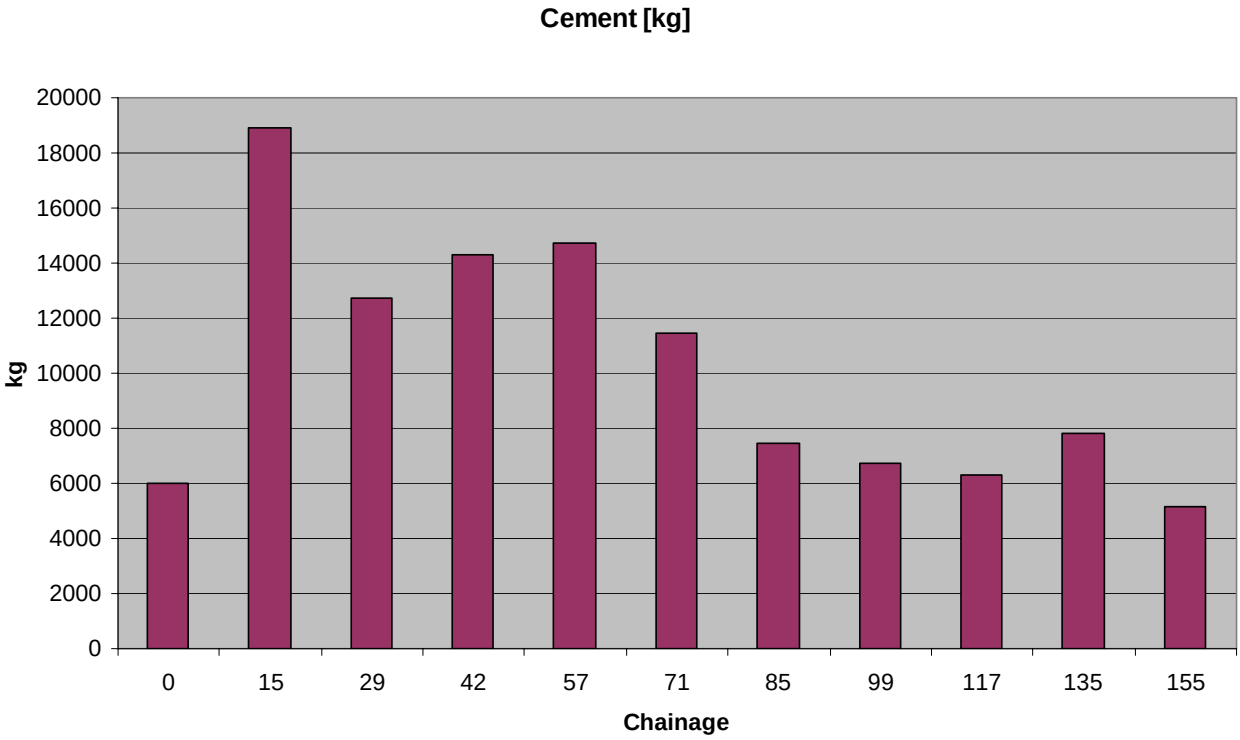

***Figure 3**. Total weight of the grouting cement used in ONKALO.*

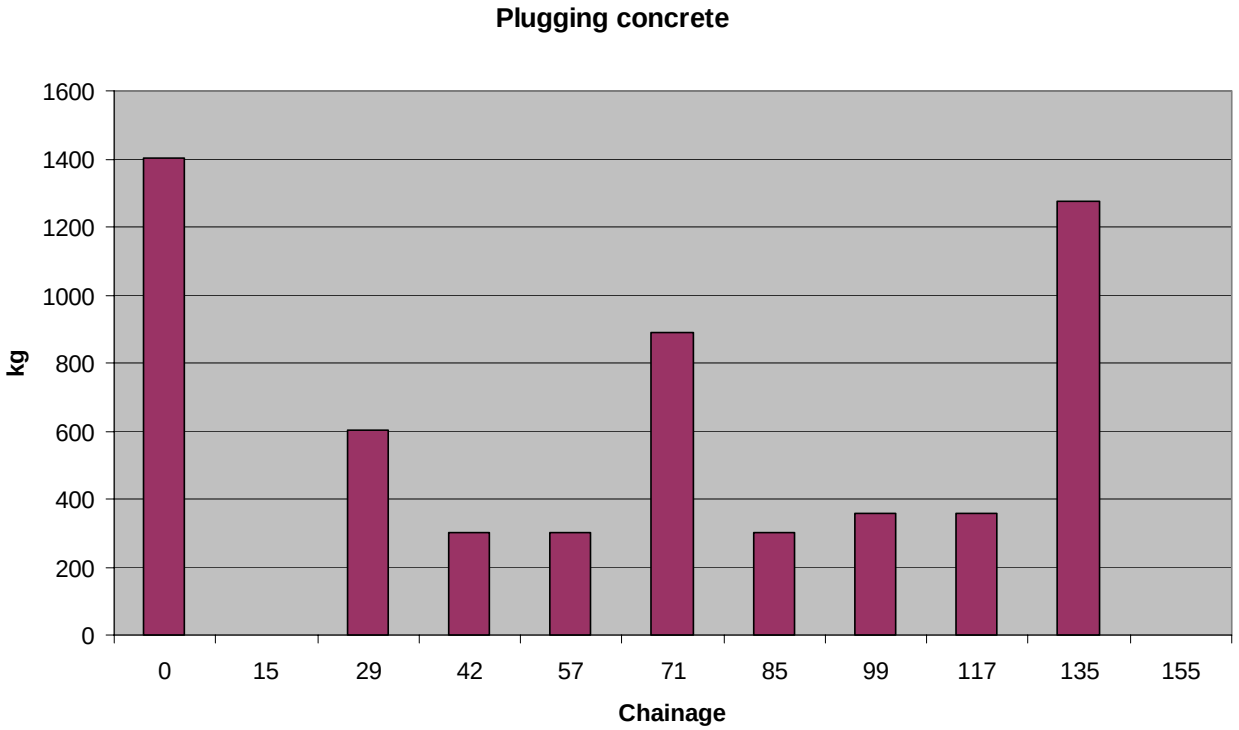

***Figure 4**. Weight of the plugging concrete used in ONKALO.*

APPENDIX 2

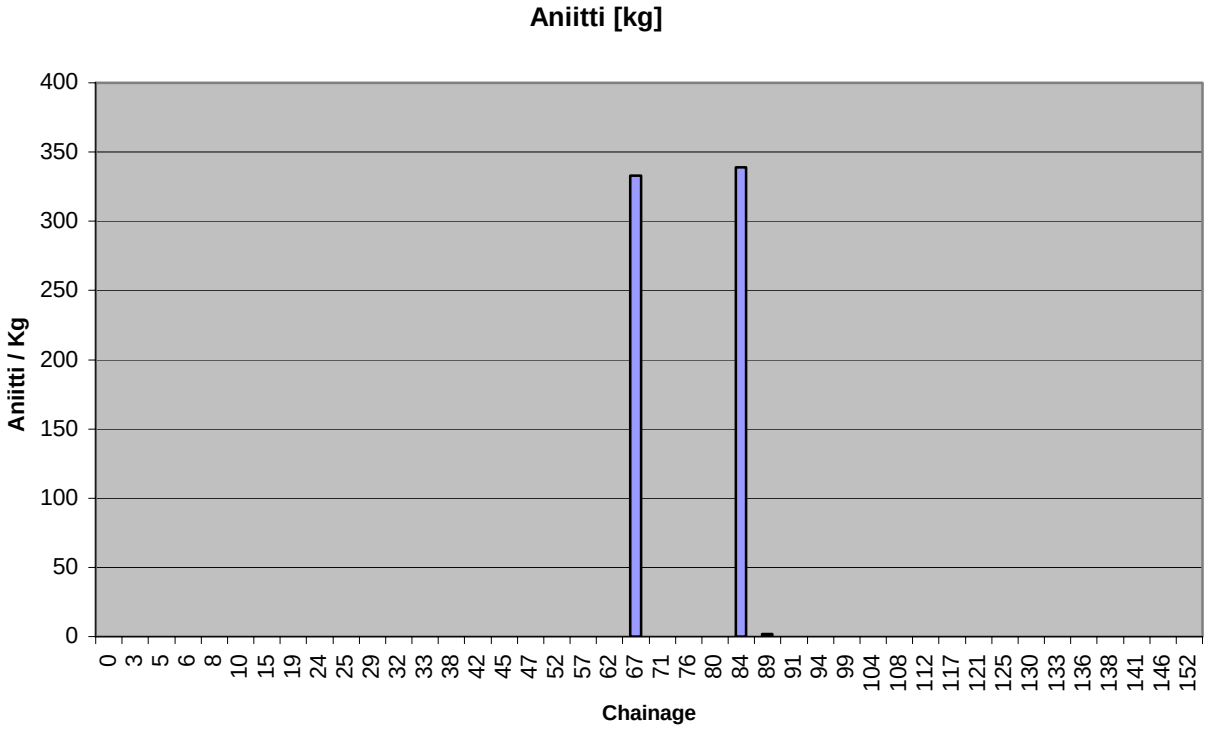

Figure 5. *Weight of Anite used as explosive in ONKALO.*

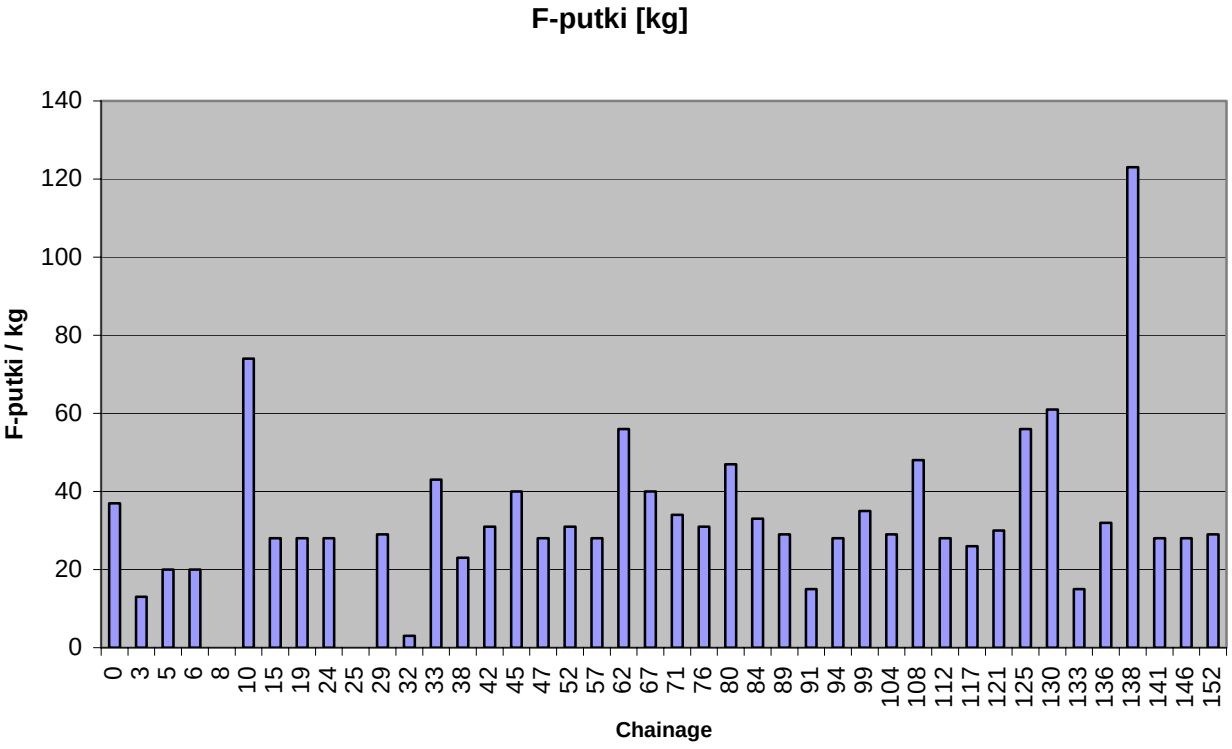

Figure 6. *Weight of F-17 x 40 pipe charge used in ONKALO.*

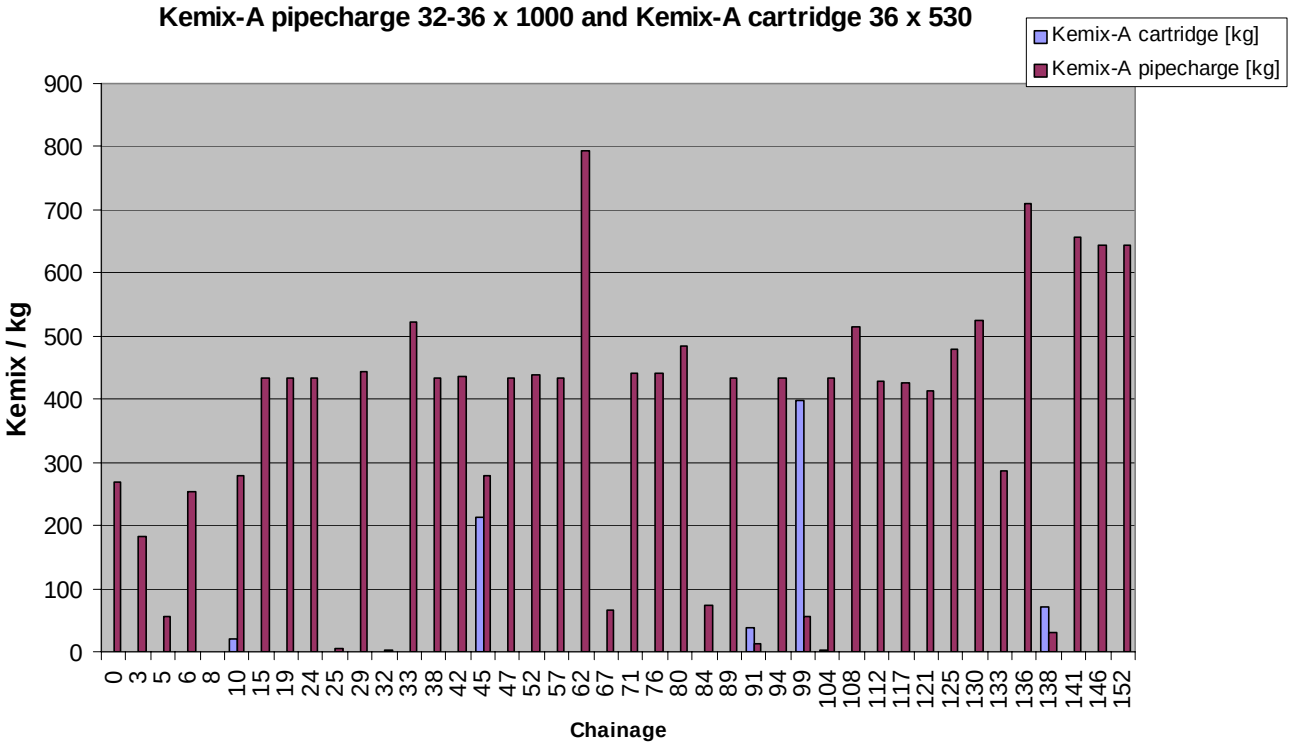

***Figure 7**. Weight of Kemix-A pipe charge and Kemix-A cartridge used in ONKALO.*

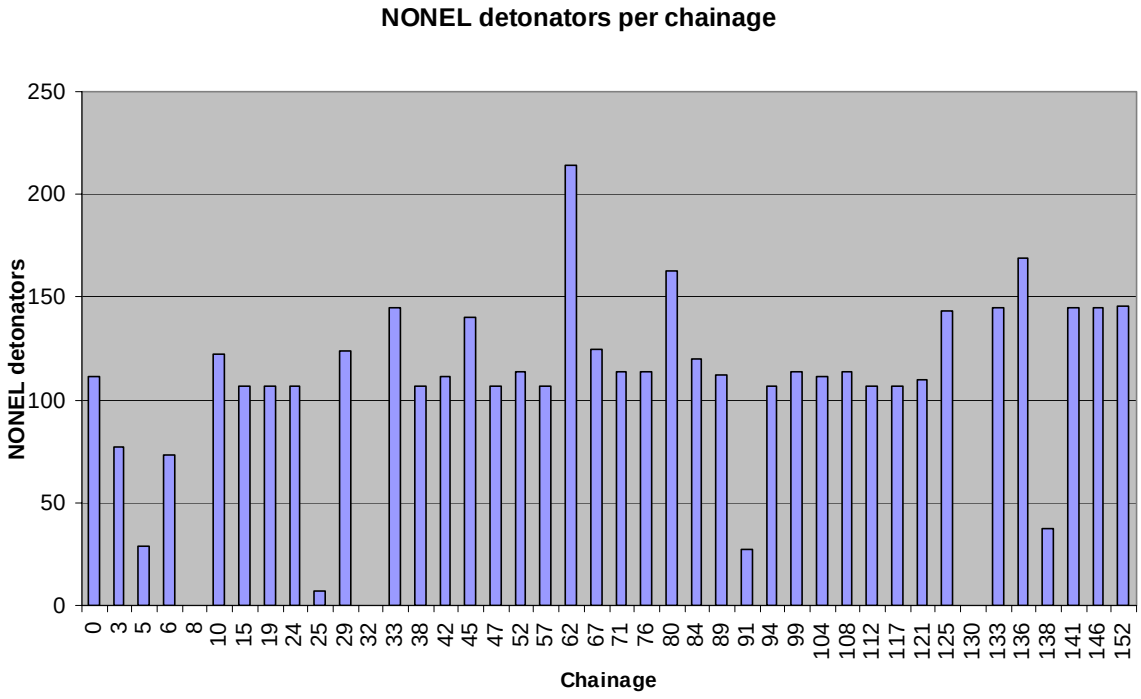

***Figure 8**. Number of NONEL detanators used in ONKALO.*

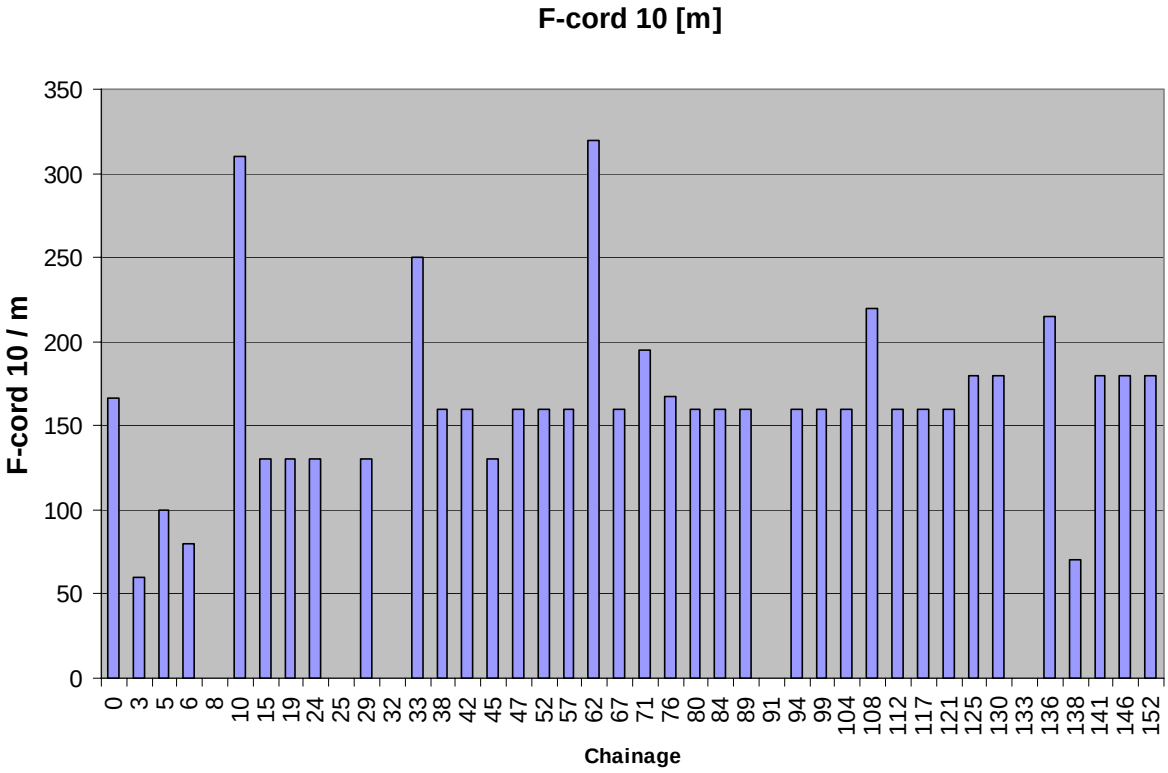

***Figure 9**. Length of F-cord 10 used in ONKALO.*