ThorCon™

Fuel Salt Specification

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1 Salt specification

ThorCon uses six salt mixtures:

1. Fuelsalt contains fissile, fertile and fission product material and is used for primary loop heat transfer. It contains both thorium and fissile uranium.
2. Makeupsalt is a fuelsalt that contains no thorium, just fissile uranium. It is slowly added as the reactor consumes the fissile.
3. Makeupfertile is a fuelsalt that contains no uranium, just thorium. This is used to reduce reactivity during extended power down period.
4. Testsalt is a Fuelsalt that contains un-enriched uranium. It is used in the demonstrator for non-radiactive testing.
5. Secsalt is used for secondary loop heat transfer. It is also our rinse/flush salt. It is virgin nabe with no heavy metals.
6. Solsalt used for tertiary loop heat transfer

We may also want to prepare some dirty Testsalt that approximates expected composition after several years of fission product and structural corrosion buildup.

1.1 Fuelsalt, Makeupsalt, Makeupfertile, testsalt, and secsalt

Nominal baseline fuelsalt composition is:

Material	Mol-percent	Weight-percent
NaF	71	39.93
BeF2	16	10.07
ThF4	9	37.12
UF4	2	8.41
ZrF4	2	4.48

Tolerance is TBD but estimated at +/-0.5%.

The uranium composition is LEU19, natural uranium enriched to 19.75% 235U.

Makeupsalt is the same as Fuelsalt except that the ThF4 is replaced with more UF4 (LEU19) and some slight adjustments increasing the uranium fraction and decreasing the beryllium fraction to compensate for burn-up effects.

Makeupfertile is the same as Fuelsalt except that the UF4 is replaced with more ThF4.

Testsalt is the same as Fuelsalt except that it uses natural or depleted uranium rather than LEU19.

Nominal Secsalt composition is:

Material	Mol-percent	Weight-percent
NaF	57	54.22
BeF2	43	45.78

The maximum allowable impurities for cleaned fuelsalt, secsalt, and testsalt are shown

in Table 1.[1] The maximum allowable impurities for incoming materials specification used

Table 1: Fuelsalt and secsalt impurity limits for cleaned salt

Impurity	Fuelsalt ppm by wt	Secsalt/Testsalt ppm by wt	
Facilitates corrosion.			Very important to clean up
S	10	10	
Fe	150	150	
Ni	150	150	
Mo	150	150	
Easy clean up items			
Moisture	5	5	
Hydrogen	5	5	
Carbon	5	5	
Neutron poisons.			Very important for fuelsalt less so for flush
B	5	25	Neutron poison
Li	50	200	6Li Neutron poison
Hf	7	15	Neutron Poison.
Zr	250	500	Unless Hf free. Natural Zr contains 1 to 3% Hf
Cd	10	200	Neutron poison
Gd	6	n/a	Neutron poison
Sm	9	n/a	Neutron poison
Eu	15	n/a	Neutron poison
Dy	60	n/a	Neutron poison
Rare earths(total)	150	200	Neutron poisons

by ORNL for MSRE are shown in Table 2. Our specification will be similar but should be adjusted based on difficulty of cleaning and normal impurities of incoming materials. It is expected that incoming material will require drying, if only to remove moisture absorbed during shipping. Moisture and carbon are easily removed. Oxides vary in difficulty. Sulfur is the most difficult to remove. No attempt is made to remove neutron poisons they are required to be low in the incoming material.

[1] This fuelsalt specification is based on ORNL-4616.

Table 2: Incoming material impurity limits from ORNL for MSRE

Water	1000	Drying of incoming material is presumed
S	250	Important! Difficult to remove
Fe	100	Contributes to corrosion
Ni	25	Contributes to corrosion
B	5	B-10 neutron poison
Li (natural)	50	Li-6 neutron poison
Zr (natural)	250	Hf neutron poison
Cd	10	Neutron poison
Rare earths (total)	10	Neutron poison except Thorium Fluoride

Fuelsalt and testsalt contain thorium. Thorium is commonly found associated with rare earth elements. Some of these rare earths, most notably Sm, Gd, Eu, and Nd contain significant neutron poison isotopes. The fuelsalt should have low enough concentrations of these impurities that it does not significantly impact the reactor. Other allocations of the neutron absorbing elements (6Li, Cd, Gd, Sm, Eu, and Hf) are allowable as long as they result in the same or less neutron absorption.

For convenience, Table 3 shows the allowable impurity levels of lanthanides in thorium used to make fuelsalt, expressed as ppm by weight relative to thorium weight.

Table 3: Thorium specification for fuelsalt

Element	Max Impurity Level (ppm in Th)
Gd	20
Sm	30
Eu	50
Dy	200
Total Lanthanides	500

1.2 Solsalt

Nominal Solsalt composition is standard commercial grade, 60:40 non-eutectic composition: The minimum melting point eutectic composition is 49 mol percent sodium nitrate which corresponds to about 45 weight percent sodium nitrate. But potassium nitrate is higher cost than sodium nitrate, so the industry standard, cost-reduction compromise is to bump up the sodium nitrate fraction to 60 weight percent. Example supplier is SQM.

Material	Mol-percent	Weight-percent
NaNO3	64	60
KNO3	36	40

Impurities are shown in Table 4.

Table 4: Solsalt Impurity Specification

Impurities	Max allowable ppm
Chlorine (Cl)	1000
Perchlorate (CLO4)	350
Moisture (H2O)	1000
Nitrite (NO2)	200
Magnesium (Mg)	200
Sulphate (SO4)	1000
Carbonate (CO3)	1000
Hydroxil (OH)	500
Total all impurities	5000

Impurities in the solar salt are less critical as they do not impact the neutronics performance.