



References

in Potash and Salt Processing

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The company Kali-Umwelttechnik GmbH Sondershausen is the sole legal successor of the former Potash Research Institute. The Potash Research Institute was integrated in the management of the “VEB KOMBINAT KALI”, the government owned combination for potash production in the former GDR. “VEB KOMBINAT KALI” was the third largest potash exporter of the world and operates a large number of mining and processing facilities:

- 11 Potash mines
- 1 Rock salt mine
- 3 Solution mining facilities
- 3 Mining facilities for other minerals
- 11 Potash processing plants
- 1 Rock salt processing plant
- 1 Dead burnt magnesia plant.

All these units were supervised by the engineers and scientists of the Potash Research Institute. Scientific investigations, development of new technologies for mining and ore process as well as development of potash typical equipment was the main task of this institute.

Proceeding from that background Kali-Umwelttechnik GmbH (K-UTECH) can resort to more than 50 years experiences in potash and salt industries.

	Location	Size	Year	Remarks
<p>Sylvite flotation</p> <p>Development of the mining and processing design of Europe largest potash plant including optimisation and product quality management based on Sylvite ore</p>	Zielitz Germany	25,000 t/d raw potash ore 1,500,000 t KCl/y potash fertiliser	1962 - 1989	<p>The entire operation beginning at the cores from the exploration wells up to the final KCl product, including the complete underground and above ground technology was designed by the KFI-Sondershausen.</p> <p>Each single process step was tested at the laboratory and at small scale pilot tests.</p> <p>Since 1980 an optimization programme was carried out in order to improve the product quality by compaction, anticaking and dedusting.</p>
<p>Hot crystallisation of KCl</p> <p>Development of process design for KCl 99 production</p>	Zielitz Germany	300,000 t KCl/y KCl 99	1992 - 1993	Based on Sylvite from the mine the process design for the production of high grade potassium chloride for electrolysis has been carried out by K-UTEC.
<p>Hot crystallisation of KCl</p> <p>Development of process design for KCl production based on a <i>Sylvite-Carnallite-Kieserite</i> ore</p>	Merkers/Werra Germany	25,000 t/d raw potash ore 1,500,000 t KCl/y potash fertiliser	1976 – 1980	Based on the complicated raw potash ore a hot dissolution an crystallisation process for 2 x 1,200 m ³ /h flow rate was designed by KFI-Sondershausen.

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<p>Hot crystallisation of KCl</p> <p>Development of process design for KCl production based on a <i>Sylvite-Anhydrite-Kieserite</i> ore</p>	<p>Bischofferode Germany</p>	<p>10,000 t/d raw potash ore 800,000 t KCl/y potash fertiliser</p>	<p>1972 – 1978</p>	<p>Based on the complicated raw potash ore a hot dissolution a crystallisation process for production of dust free potash fertiliser was designed by KFI-Sondershausen.</p>
<p>Sylvite flotation</p> <p>Development of processing design of potash plant based on a sulphate rich <i>Sylvite</i> ore</p>	<p>Roßleben Germany</p>	<p>10,000 t/d raw potash ore 1,000,000 t KCl/y potash-magnesia fertiliser</p>	<p>1966 – 1974</p>	<p>Considering the complicated raw potash ore a hot dissolution and crystallisation process was converted into a flotation process for K-Mg-potash fertiliser.</p>
<p>Beneficiation of NaCl</p> <p>Development of process design for NaCl production based on rock salt</p>	<p>Roßleben Germany</p>	<p>3,000,000 t NaCl/y NaCl production</p>	<p>1966 – 1974</p>	<p>The basic engineering for production of table salt and industrial salt was carried out by KFI-Sondershausen.</p>
<p>Halite / Kieserite flotation</p> <p>Development of process design of a flotation plant based on <i>dissolution residue</i> from a hot dissolution operation of a <i>Sylvite-Carnallite-Kieserite</i> ore</p>	<p>Unterebreizbach /Werra Germany</p>	<p>2,000,000 t/y dissolution residue</p>	<p>1991</p>	<p>The dissolution residues from a hot dissolution process of carnallite ore were used for a flotation process for MgSO₄ production.</p>

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<p>Halite flotation</p> <p>Development of process design of a flotation plant based on <i>raw halite</i> ore</p>	Bernburg Germany	pilot plant	1993	The process design for production of high grade salt (99,8 %) for electrolysis by flotation was carried out by K-UTEC.
<p>Cold crystallisation of KCl</p> <p>Development of process design for KCl production based on <i>Carnallite from solar evaporation</i></p>	Zarsi Tunisia	pilot plant reactor size 1 m ³	1984 – 1985	KFI-Sondershausen did run the pilot test plant including first crystal growth crystallizer in the world Sebkal el Melah / Zaris jointly with Spie-Batignolles, MdPA, Swenson, Whiting-Fermont, Salines de Midi for SDICS.
<p>Carnallite dissolution</p> <p>Carnallite decomposition</p> <p>Cooling crystallisation of carnallite</p> <p>Development of process design for KCl, MgCl₂ and NaCl production based on <i>MgCl₂ brines from Carnallite solution mining</i></p>	Bleicherode Germany	120,000 t KCl/y high grade KCl 60,000 t MgCl ₂ /y MgCl ₂ brine	1975 - 1989	<p>The process design was carried out beginning from lab test up to large scale pilot tests by the KFI-Sondershausen. A very wide range of alternative process steps were investigated in detail.</p> <p>As result the first plant for carnallite solution mining and brine processing to potash fertiliser in the world started in 1989.</p>

	Location	Size	Year	Remarks
<p>Cooling crystallisation of KCl Hot leaching NaCl separation MgCl₂ brine evaporation</p> <p>Development of process design for KCl, MgCl₂ and NaCl production based on <i>MgCl₂ brines from Carnallite solution mining</i></p>	<p>Bleicherode Germany</p>	<p>50,000 t KCl/y high grade KCl</p> <p>60,000 t MgCl₂/y MgCl₂ brine and Bischofite flakes</p>	<p>1990 - 1996</p>	<p>The K-UTEC designed the up grading process of the KCl and MgCl₂ products and the scheduled up scaling of the entire operation.</p> <p>Especially basic engineering for the energy efficient up grading of MgCl₂ brines by evaporation up to a level of 500 g/l was generated.</p>
<p>Carnallite decomposition Hot thickening MgCl₂ brine evaporation</p> <p>Process consulting and process design for high grade MgCl₂ brine production based on <i>MgCl₂ brines</i> from a conventional carnallite mining Carnallite solution mining and processing operation</p>	<p>Sondershausen Germany</p>	<p>500,000 t/y MgCl₂ brine</p>	<p>1983 - 1990</p>	<p>Consulting service for the energy up grading of MgCl₂ brines by evaporation up to a level of 500 g/l was provided. Especially the hot thickening of sulphates at brines with a high viscosity was designed.</p>

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<p>Compaction of KCl</p> <p>Development of the process design for KCl compaction plants based on a <i>wide variety of KCl products (contamination)</i> including the post treatment</p>	<p>K+S/Germany APC/Jordan Sylvinite/Russia Uralkali/Russia Byeloruskali/ Byelorussia Oriana/Ukraine</p>	<p>Commercial plants of standard sizes</p>	<p>1992 - 1996</p>	<p>The K-UTEC designed the compaction process of the KCl including the selection and testing of the equipment.</p>
<p>MgCl₂-brine evaporation</p> <p>Cooling crystallisation of carnallite Development of the process design for synthetic carnallite production based on <i>MgCl₂ brines</i></p>	<p>Confidential</p>	<p>bench scale tests for app. 750,000 t/y high grade synthetic carnallite</p>	<p>1996</p>	<p>The K-UTEC is subcontractor for process design and verifying the process steps by bench scale tests using original raw materials.</p>
<p>Carnallite-halite flotation</p> <p>Consulting service for a flotation plant based on <i>carnallite from solar evaporation</i></p>	<p>Jordan</p>	<p>test plant</p>	<p>1995 – 1996</p>	<p>Consulting service and development of a new flotation agency was carried out by K-UTEC.</p>
<p>Crystallisation of K₂SO₄</p> <p>Development of the process design for K₂SO₄ production based on <i>Na₂SO₄ and KCl</i></p>	<p>China</p>	<p>50,000 t/y potassium sulphate</p>	<p>1993</p>	<p>The process design was carried out by K-UTEC.</p>
<p>Crystallisation of K₂SO₄</p> <p>Development of the process design for K₂SO₄ production based on <i>Na₂SO₄ and</i></p>	<p>Russia</p>	<p>50,000 t/y</p>	<p>1993</p>	<p>The process design was carried out by</p>

	Location	Size	Year	Remarks
<i>KCl</i>		potassium sulphate		K-UTEC.
NaCl production Development of the process design for NaCl production based on <i>rock salt</i>	Subcontractor of a German equipment supplier	Bench scale	1992 – 1993	Bench scale test and preliminary process design was carried out by K-UTEC.
KCl production Development of the process design for KCl production based on <i>disposal brines of coal mines</i>	Subcontractor of a German equipment supplier	15,000 t/y KCl	1995 – 1996	Consulting and preliminary process design was carried out by K-UTEC.
KCl 99 production Development of the process design for KCl 99 production based on <i>dust KCl from potash production</i>	Subcontractor of a German equipment supplier	50,000 t/y KCl	1995 – 1996	Bench scale test and preliminary process design was carried out by K-UTEC.
KCl 99 production Development of the process design for KCl 99 production based on <i>synthetic carnallite</i>	Subcontractor of a German equipment supplier	Bench scale	1995 – 1996	Consulting and preliminary process design for KCl for electrolysis was provided.
Natural cooling Carnallite crystallisation	NEDMAG Industries B.V.	Small scale Pilot tests of cold crystallisation	1996	The process design for the KCl production was generated.

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Carnallite decomposition Development of the process design for KCl production based on <i>carnallite and bischofite brines</i>	Veendam/The Netherlands	of carnallite in a crystal growth decomposer		
Hot leaching NaCl separation Cooling crystallisation of KCl Development of the process design for KCl and NaCl production based on <i>spent salt melt</i>	Hannover/ Germany	Pilot plant Original raw material by-pass plant	1993 - 1994	The K-UTEC designed the dissolution and cooling process of the KCl and NaCl products.
KCl production Development of the process design for KCl and NaCl production based on <i>sylvite ore</i>	Middle Asia	app. 1,000,000 t/y KCl app. 1,000,000 t/y NaCl	1996	Consulting and preliminary process design was carried out by K-UTEC.
MgCl₂- and Mg-products Development of the process design for MgCl ₂ products based on <i>carnallite and bischofite brines</i>	Veendam/The Netherlands	Bench scale tests Pilot tests	1995 – 1996	The process design was generated and the test work was carried out by K-UTEC, Test work for precipitation and purification of Mg(OH) ₂ with slaked dolomite
Carnallite-halite separation Development of the process design for wet separation of carnallite and halite based on	Bleicherode/	Pilot tests	1995 – 1996	The process design was generated and

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<i>synthetic carnallite</i>	Germany			the test work was carried out by K-UTEC.
MgCl₂ brine disposal Development of the process design for MgCl ₂ brine solidification based on <i>MgCl₂ disposal brine</i>	Staßfurt/ Germany	Bench scale tests pilot test	1996	The process design for solidification and disposal technology was developed and related test work was carried out by K-UTEC.
Storage and loading terminal Basic and detail engineering for KCl storage, land and sea terminal	Zielitz/Germany Zielitz/Germany Rostock/ Germany Rostock/ Germany	60,000 t KCl 99 10,000 t 100,000 t	1984 1996	potash fertiliser storage KCl 99 storage storage and sea terminal for potash fertiliser sea terminal for MgCl ₂ brine
Potash and Mg-products from natural brines Development of the process design	Khor/Iran	Pilot plant 1 t/d test work / pilot plant	1997 1997	Based on the natural brines of the Playa Khor in Central-Iran by solar evaporation and carnallite crystallisation technology of K-UTEC

	Location	Size	Year	Remarks
		pre-feasibility study 1,000 kt/y NaCl	1998 – 1999	
		feasibility study 50,000 t/y KCl	1998 – 1999	
		process design 100 kt/y KCl / Mg(OH) ₂	1999	
		basic engineering	2001	
Magnesium sulphate production Development of the process design	NEDMAG Industries B.V. Veendam/The Netherlands	20,000 t/y Epsomite	1997	Test work and Process design Crystallisation of Epsomite by Conversion of MgCl ₂ from brines and several sulphates
Potash and NaCl plant	Dechkhanabad/ Uzbekistan	Feasibility study 500 kt/y KCl 500 kt/y NaCl	1998	

	Location	Size	Year	Remarks
		process design	1999	
Carnallite dissolution Carnallite decomposition Cooling crystallisation of carnallite Cooling crystallisation of KCl Hot leaching NaCl separation MgCl₂ brine evaporation Development of the process design for KCl and NaCl production based on <i>MgCl₂ brines from carnallite -thachhydrite ore from solution mining</i>	Pimai/Thailand	High grade KCl High grade NaCl	1996	Pre-feasibility investigations were carried out by K-UTEC.
Carnallite cooling crystallisation plant	Mithapur/India	Technological study	1998	based on bitterns by K-UTEC processing
KCl 99 production plant	Mithapur/India	Technological study	1998	based on bitterns by K-UTEC processing
Mg(OH)₂ production	Mithapur/India	Technological study for 200 kt/y Mg(OH) ₂	1998 – 1999	High Purity Product Based on carnallite decomposition liquor and ammonia (continuous precipitation by K-UTEC processing)

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MgCl₂ solidification by gelatinising of MgCl₂ brines	Staßfurt/ Germany	Stabilisation of brine filled shafts Stabilisation of shafts in potash mines	1997 – 1999	Development and first utilisation of a new technology for solidification of highly concentrated MgCl ₂ brines using the patented K-UTEC process
	Wolfenbüttel and Bischofferode/ Germany	Stabilisation of dams in former potash mines	1998 – 2000	Utilisation of gelling technologies for stabilisation or building of dams in former potash mines using the patented K-UTEC process.
Magnesium sulphate production Test work Process study	DEUSA in Bleicherode/ Germany	30,000 t/y	1999 / 2000	Conversion of MgCl ₂ with Na ₂ SO ₄
K₂SO₄ production	China	50,000 t/y	2000	Test work for process optimisation, process design
Waste water treatment	B.U.S Freiberg/ Germany	80,000 t/y	2002	Test work and process design for a Zero- Disposal-Plant, Crystallisation of 10,000 t/y Halite, Glaserite, Sylvite in a Thermocompression Plant

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NaCl 99 Production	Bleicherode/ Germany	30,000 t/y	2002/03	Test work and draft of process design for purification of NaCl
KCl 99 Production	Bleicherode/ Germany	20,000 t/y	2002/03	Test work and process and draft of design for production of KCl 99
KCl 95 Production	IMIDRO Khor/Iran	50,000 t/y	2002	Basic engineering (Collaboration with ITCEN) based on natural brines of the dessert Dasht e Kavir, Brine Winning System, Solar Evaporation Plant (area 14 km ²), Potash Production Facility
Mg(OH)₂ Production	IMIDRO Khor/Iran	40,000 t/y	2002	Basic engineering (Collaboration with ITCEN), based on brine from the above mentioned Potash Production Facility
NaCl Production	Iran/Pars Namak/ Ebner Apparate und Anlagen/ Germany	250,000 t/y	2003	Test Work and Basic Design for Brine Purification Plant

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Boron Acid Production	Arica/Chile/ Quiborax	90,000 t/y	2003	Study and Basic layout for Boron Acid Production Facility based on Ulexite, Leaching, Crystallisation, Evaporation of Mother Liquor in Solar Ponds (area: 250,000 m ²)
SOP Production	Ebensee/ Austria/Salinen Austria AG	15,000 t/y	2004	Feasibility Study and Basic engineering of a Potassium Sulphate Plant based on brine from the Sodium Chloride Production Facility in Ebensee
NaCl salt washing	Iran Arvand Petrochemical Company	2,000,000 tpa washed NaCl salt	Under construction	Process Design and Basic Engineering

	Location	Size	Year	Remarks
<p>Production of Sodium Sulphate as By-product of Potash Production Development of special process stages Consultant for process optimisation</p>	Merkers/Rhön Germany	150,000 t/y Na ₂ SO ₄	Up to 1993	<p>KFI and later K-UTEC worked as a consultant for the owner.</p> <p>Process assessment and optimisation were carried out.</p> <p>Investigations for several Process stages.</p> <p>The process worked by cooling crystallisation of Na₂SO₄*10H₂O and following salting out of Na₂SO₄ with NaCl</p>
<p>Production of Sodium Sulphate from Spinning Bath Solution Development of process basics Process design, Basic engineering Commissioning and start-up</p>	Premnitz Germany	15,000 t/y Na ₂ SO ₄	1970 – 1971	<p>KFI developed a process for production of Na₂SO₄ from spinning bath solution of rayon production. The process is called as “SOMET” process.</p> <p>Main principle is the crystallisation of Na₂SO₄ by adding an organic liquid to the solution. Included in the process is the circulation of the salting out liquid.</p> <p>In 1999 K-UTEC worked as a consultant fro re-construction of the plant.</p>
<p>Production of Sodium Sulphate from Spinning Bath Solution Process design, Basic engineering</p>	Wolfen Germany	25,000 t/y Na ₂ SO ₄	1980	<p>KFI worked out the process design and basic engineering for one other plant according the “SOMET” process by order of a plant construction company.</p>

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Production of Sodium Sulphate from Natural Brine Commissioning and start-up	Lake Qarun Egypt	130,000 t/y Na ₂ SO ₄ , free of water	1991 – 1993	By order of MESSO CHEWMIETECHNIK GmbH K-UTEC took part in supervision of erection, commissioning and start-up of EMISAL's sodium sulphate plant at Lake Qarun/Egypt. Raw material resource is salty water from Lake Qarun. Main operating principles of the plant are pre-concentration by solar evaporation, cooling crystallisation of Na ₂ SO ₄ *10H ₂ O, melting of Na ₂ SO ₄ *10H ₂ O and following evaporation crystallisation of Na ₂ SO ₄ .
Production of Sodium Sulphate from Raw Salt Process assessment	Amlah Iran	50,000 t/y Na ₂ SO ₄ , free of water	1997	By order of the owner and a German plant construction company K-UTEC carried out an assessment study for the running process.
Production of Sodium Sulphate from Mixed Raw Salt Raw material investigations Laboratory and bench scale test work Process design	Arrak Iran	50,000 t/y Na ₂ SO ₄ , free of water	1997	By order of IMIDRO K-UTEC carried out investigations for handling of a complex raw salt, containing Glauberite, Gypsum, NaCl and Silt. Several test work was done. A design conception was worked out.

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Manufacturing Sodium Sulphate from Brine by Salting out Laboratory and bench scale test work Process design	Not specified	50,000 t/y Na ₂ SO ₄ , free of water	1999	K-UTEC carried out test work and produced a process design. Main process principles are the leaching of any Na ₂ SO ₄ containing raw salt and crystallisation of Na ₂ SO ₄ , free of water, by salting out. The process may also proceed from natural brine.
Production of Sodium Sulphate and/or Potassium Sulphate from Natural Brine Raw material investigations Laboratory and bench scale test work Feasibility study Process design	Argentina	45,000 t/y Na ₂ SO ₄ , or approx. 70,000 t/y K ₂ SO ₄ respectively	20085 - 2006	By order of "Admiralty Resources" K-UTEC carried out raw material evaluation and test work for recovery of lithium salts from lake brine. As a by-product is obtained Na ₂ SO ₄ , which is to purify. The Na ₂ SO ₄ can be used directly or as intermediate product for SOP production.