

The image shows an industrial setting with a conveyor belt system. A large, stainless steel hopper or feeder is positioned above the belt. The machinery is complex, with various pipes, supports, and components. The lighting is warm and focused on the machinery, creating a sense of a busy industrial environment.

NIR REAL TIME CHEMICAL ANALYSIS OF COAL OR BIOMASS FOR PROCESS CONTROL OF GASIFICATION PROCESSES



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WHO WE ARE



ABB



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Installations & Partners



Holcim



AngloAmerican

TATA STEEL

EGA



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HOW MIGHT GASIFICATION PRODUCTIVITY AND PROFITABILITY BE OPTIMIZED?

Accurate stockpile quality

Stable resp. controlled feed

Detection and reduction of contaminants

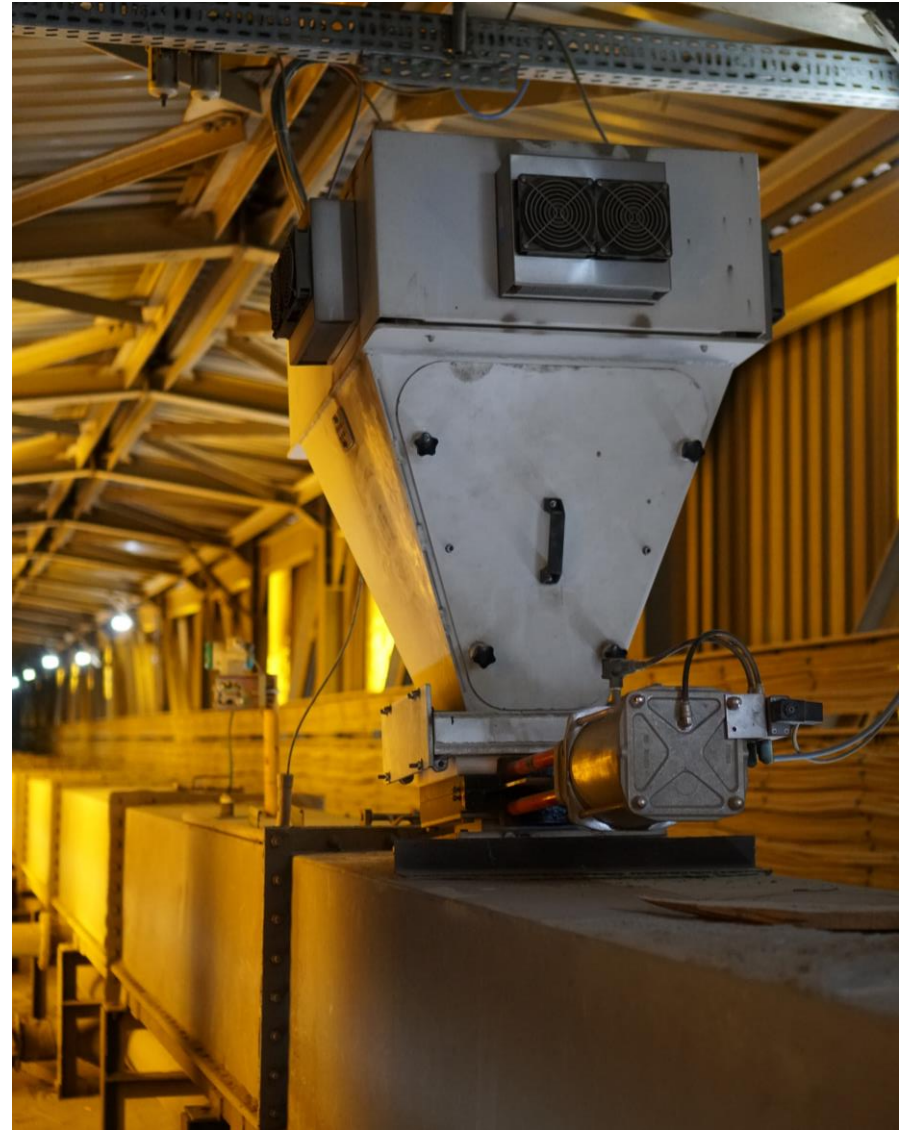
Zero unwanted waste

Active process control



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OUR SOLUTION: CROSSBELT & AIRSLIDE NIR ANALYSERS



SEAMLESS INTEGRATION INTO YOUR PROCESS IN MINE, FEED STOCK BLENDING, FEED & PROCESS CONTROL

Crossbelt
Analyser

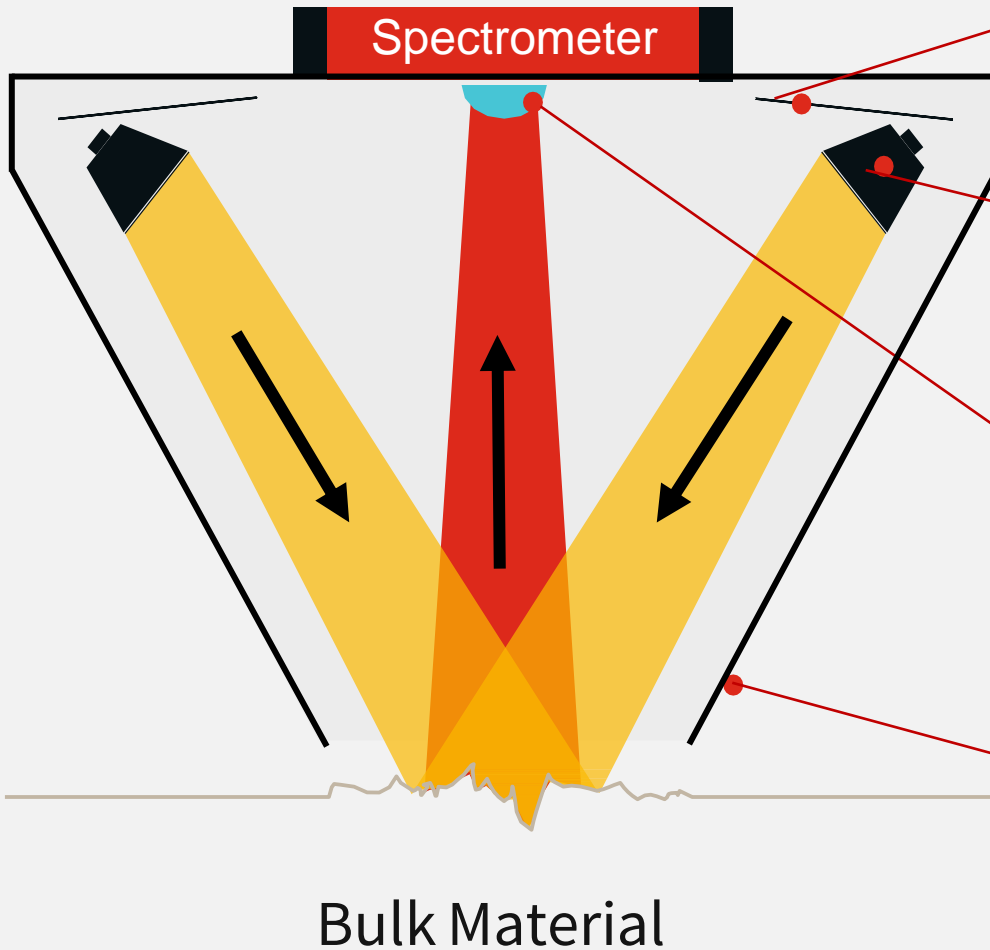


Fuels (Coal,
Alternative)



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NIR SENSING IS SIMPLE IN PRINCIPLE YET ROBUST IN PRACTICE



Rails for lamp positioning



- Halogen bulb
- 2 - 8 lamps
- 50 Watt each

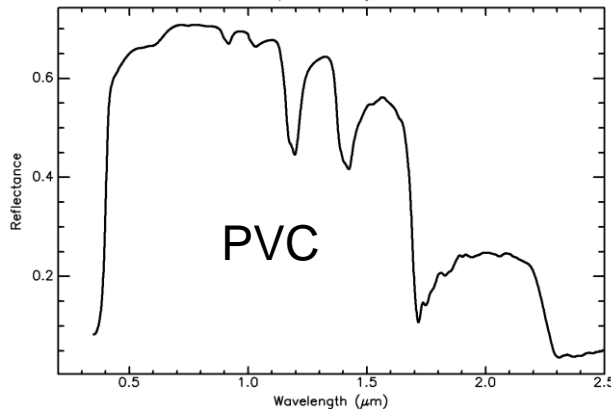
Entry lens of spectrometer

Light and dust shield



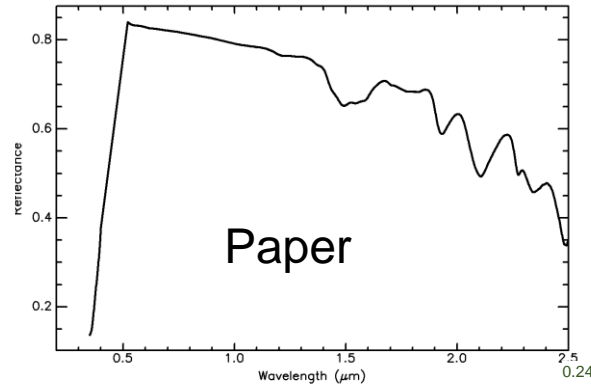
NIR FOR ORGANICS AS WELL AS MINERALS & MOISTURE

Plastic_PVC GDS338 White ASDFRa AREF (splib07a rec=19775)
Material=White PVC Pipe
Spectral Purity=a



Citation: Kokaly, R.F., Clark, R.N., Swayze, G.A., Livo, K.E., Hoefen, T.M., Pearson, N.C., Wise, R.A., Benzel, W.M., Lowers, H.A., Driscoll, R.J., and Klein, A.J., 2017, USGS Spectral Library Version 7: U.S. Geological Survey Data Series 1035, 81 p., <https://doi.org/10.3133/ds1035>
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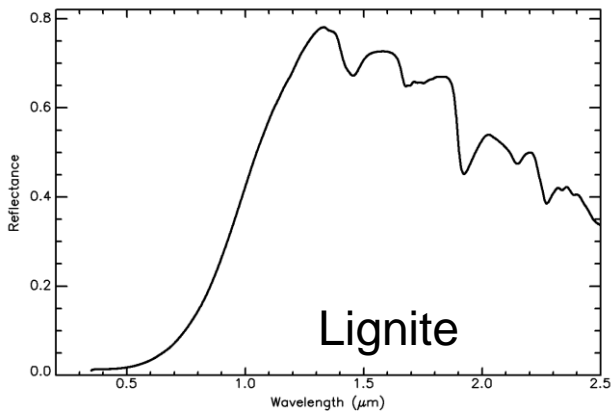
Paper_Cotton_Bond PAPR1 100% ASDFRa AREF (splib07a rec=19518)
Material=Paper
Spectral Purity=a



Citation: Kokaly, R.F., Clark, R.N., Swayze, G.A., Livo, K.E., Hoefen, T.M., Pearson, N.C., Wise, R.A., Benzel, W.M., Lowers, H.A., Driscoll, R.J., and Klein, A.J., 2017, USGS Spectral Library Version 7: U.S. Geological Survey Data Series 1035, 81 p., <https://doi.org/10.3133/ds1035>
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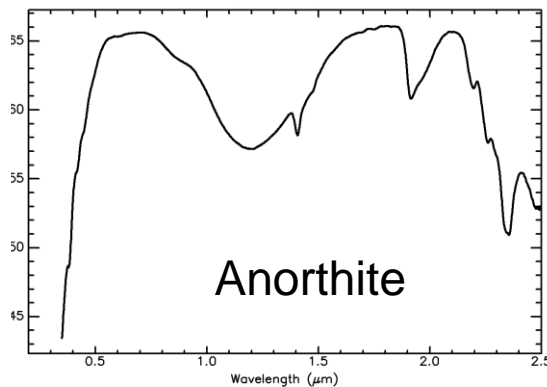
SFA NIR Spectra

Lignin_alkali SA-370959 ASDHRa AREF (splib07a rec=15345)
Formula=No defined structure, approximately (C₃H₃₄O₁₁)_n
Material=Lignin Type=Phenol; Plant Phenolic; Polyphenol
Spectral Purity=a



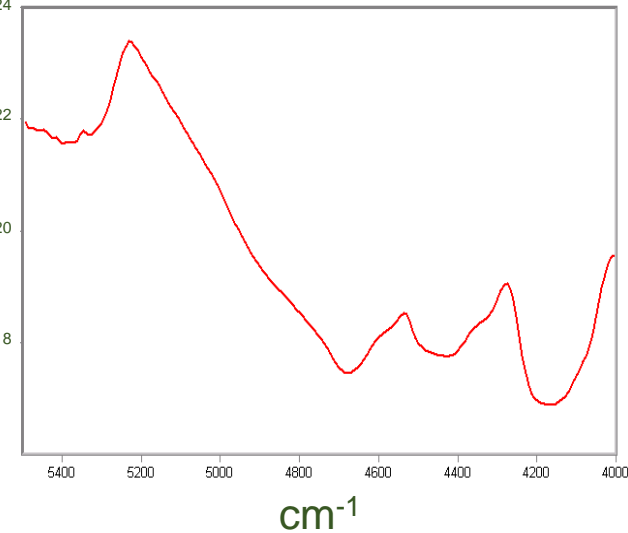
Citation: Kokaly, R.F., Clark, R.N., Swayze, G.A., Livo, K.E., Hoefen, T.M., Pearson, N.C., Wise, R.A., Benzel, W.M., Lowers, H.A., Driscoll, R.J., and Klein, A.J., 2017, USGS Spectral Library Version 7: U.S. Geological Survey Data Series 1035, 81 p., <https://doi.org/10.3133/ds1035>
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Anorthite HS349.3B Plagio ASDFRc AREF (splib07a rec=1440)
Formula=CaAl₂Si₂O₈
Material=Anorthite (Plagioclase, Ca end member, Feldspar group) Type=Tectosilicate
Spectral Purity=c



Citation: Kokaly, R.F., Clark, R.N., Swayze, G.A., Livo, K.E., Hoefen, T.M., Pearson, N.C., Wise, R.A., Benzel, W.M., Lowers, H.A., Driscoll, R.J., and Klein, A.J., 2017, USGS Spectral Library Version 7: U.S. Geological Survey Data Series 1035, 81 p., <https://doi.org/10.3133/ds1035>
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Absorbance



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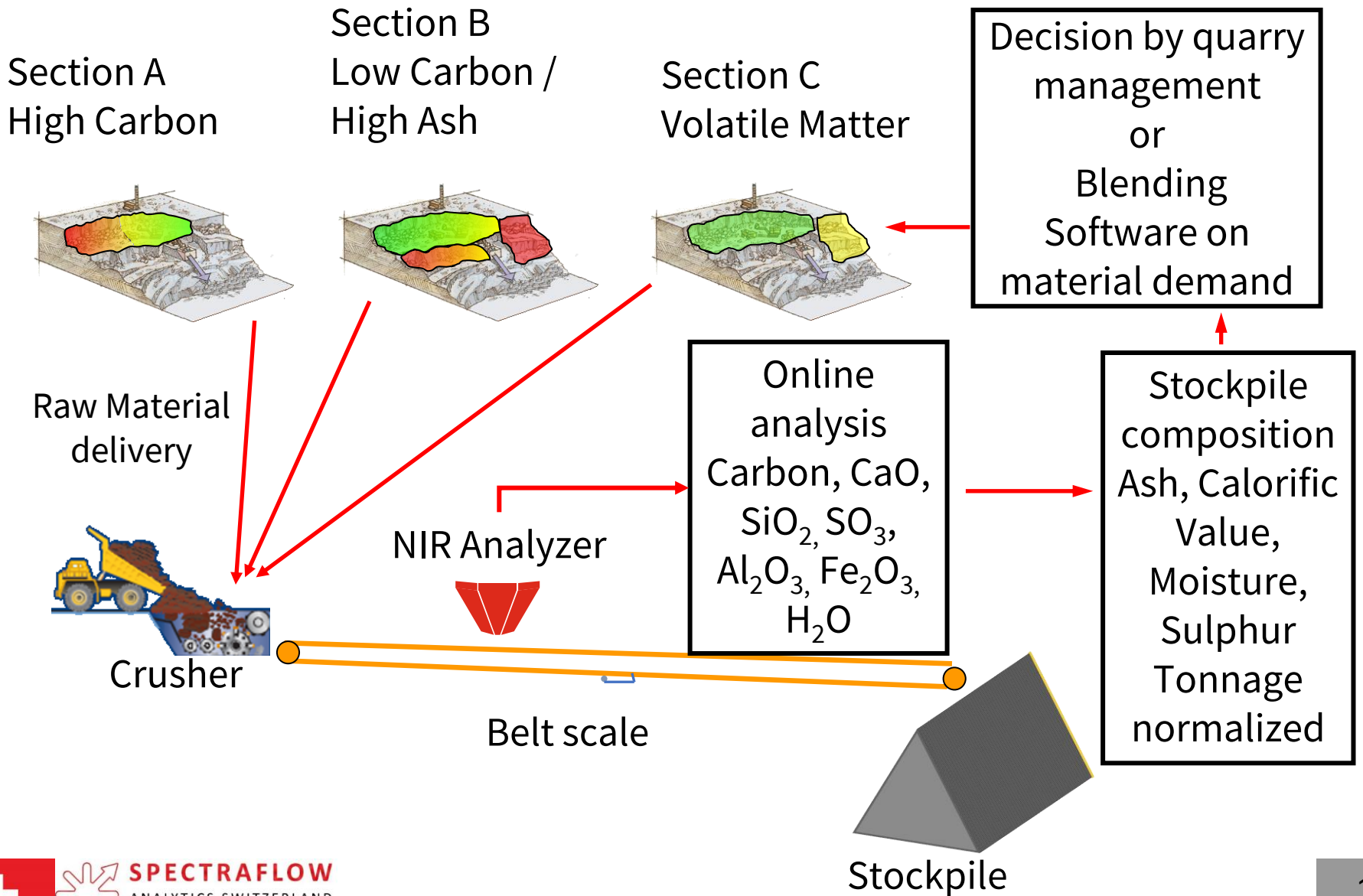
USGS Digital Spectral Library

FULL COAL, MSW OR BIOMASS ANALYSIS BY NIR

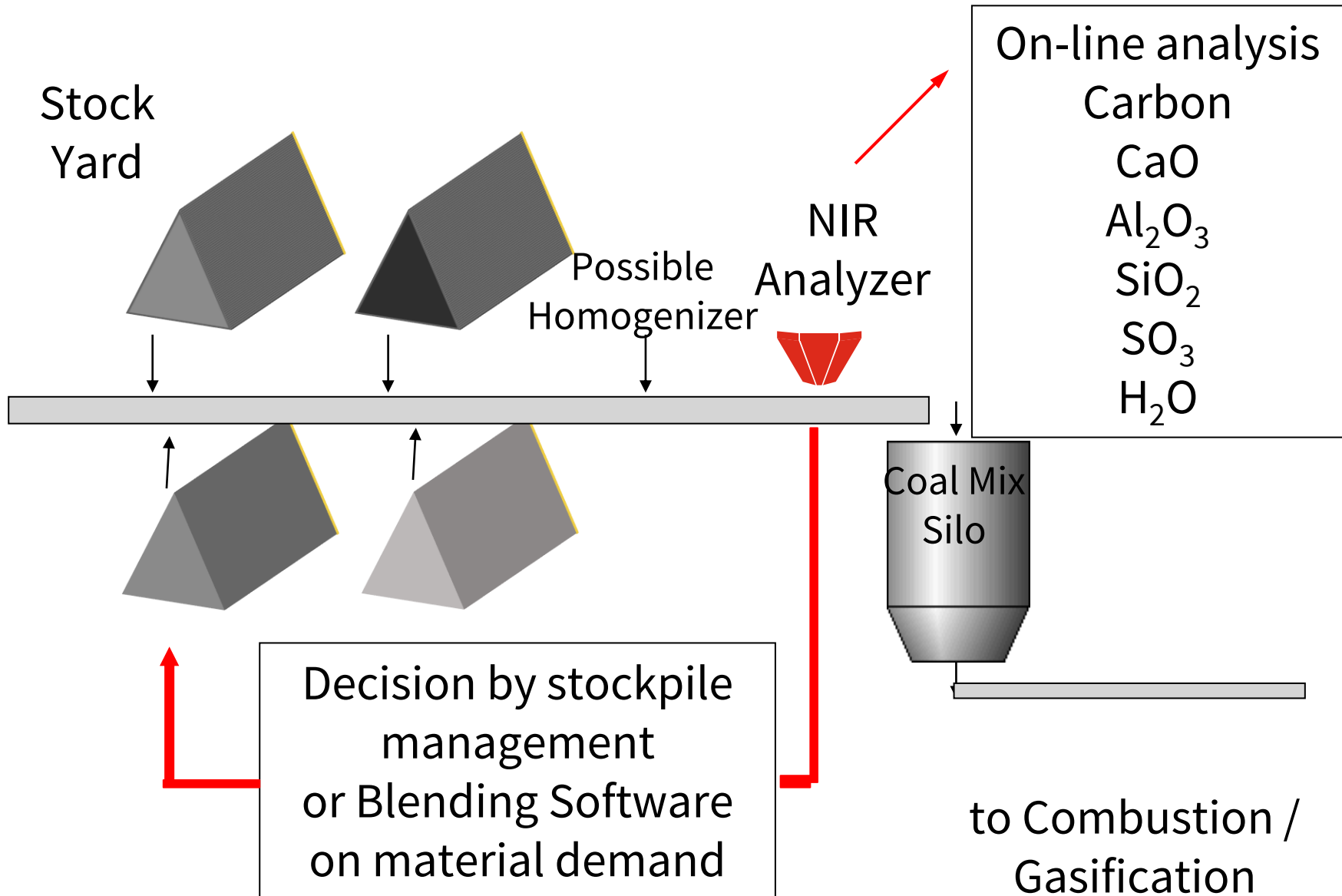
| | | | | |
|----------------|---------------------------|-----------------|-----------|---|
| total moisture | surface moisture | | Moisture | ✓ |
| | inherent moisture | | | |
| mineral matter | ash (down to oxide level) | | Inorganic | ✓ |
| | volatile mineral matter | volatile matter | | |
| | volatile organic matter | | | |
| pure coal | fixed carbon | | Organic | ✓ |



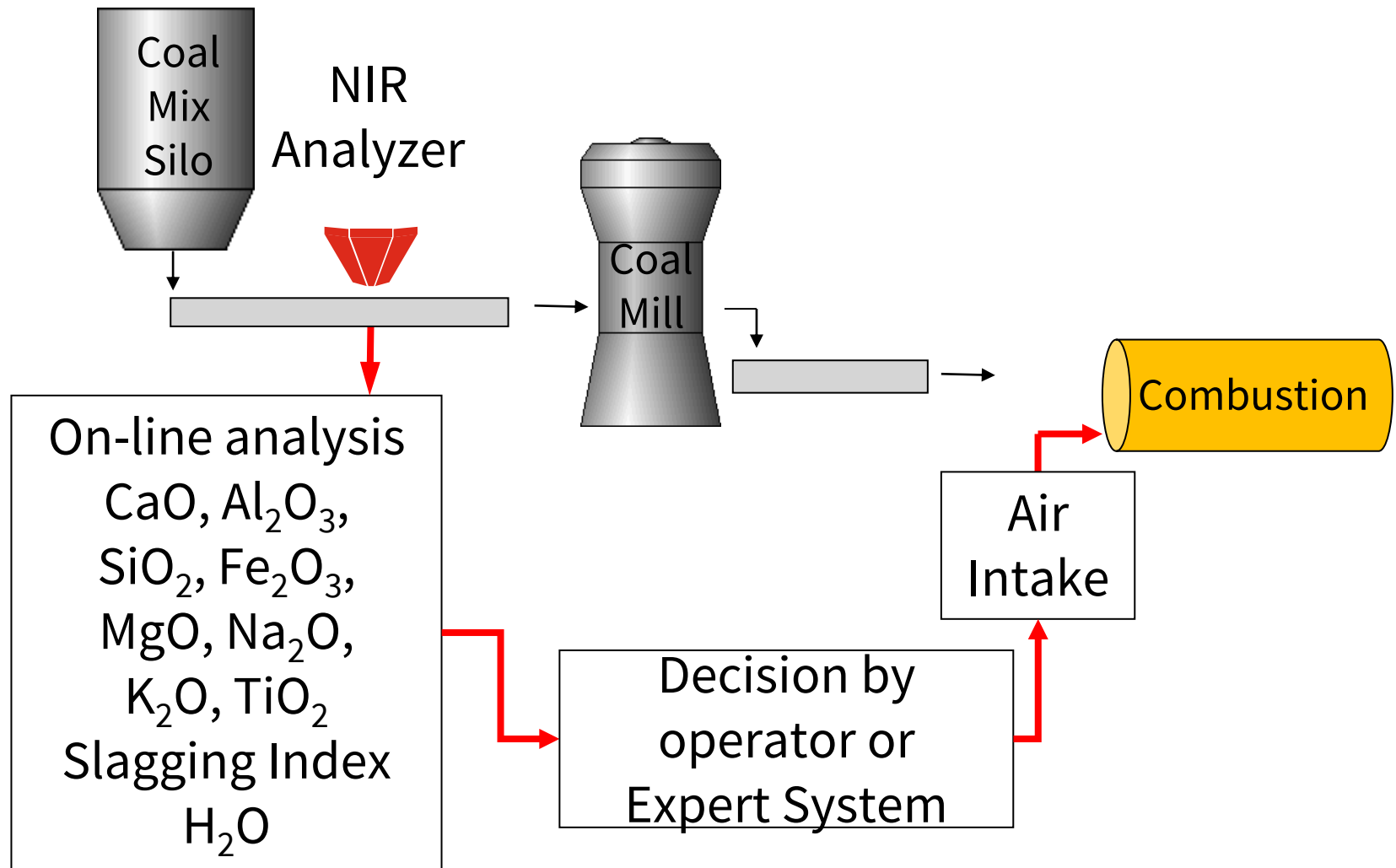
QUARRY / FEED STOCK OPTIMIZATION / BLENDING



COAL / FEED STOCK BLEND



PROCESS CONTROL



SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FUELS @ UPM

- UPM: Paper Manufacturing plant in Germany
- Paper waste
- + other municipal waste
- Control of feed to combustion
- Main Constituents:
Calorific value, Moisture, Cl

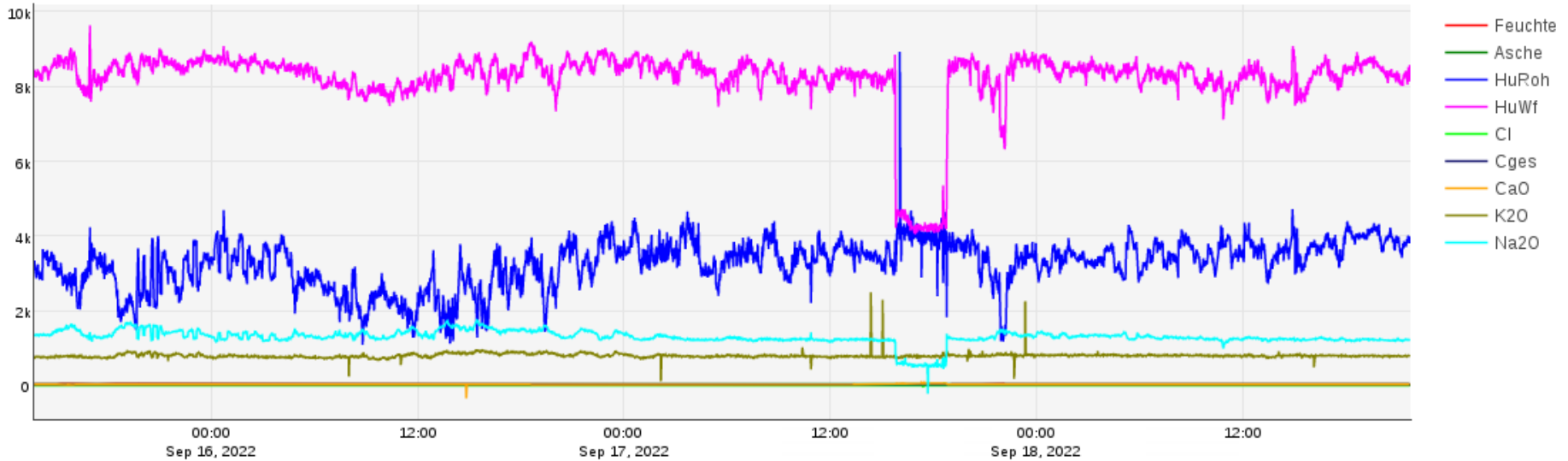


SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FUELS @ UPM

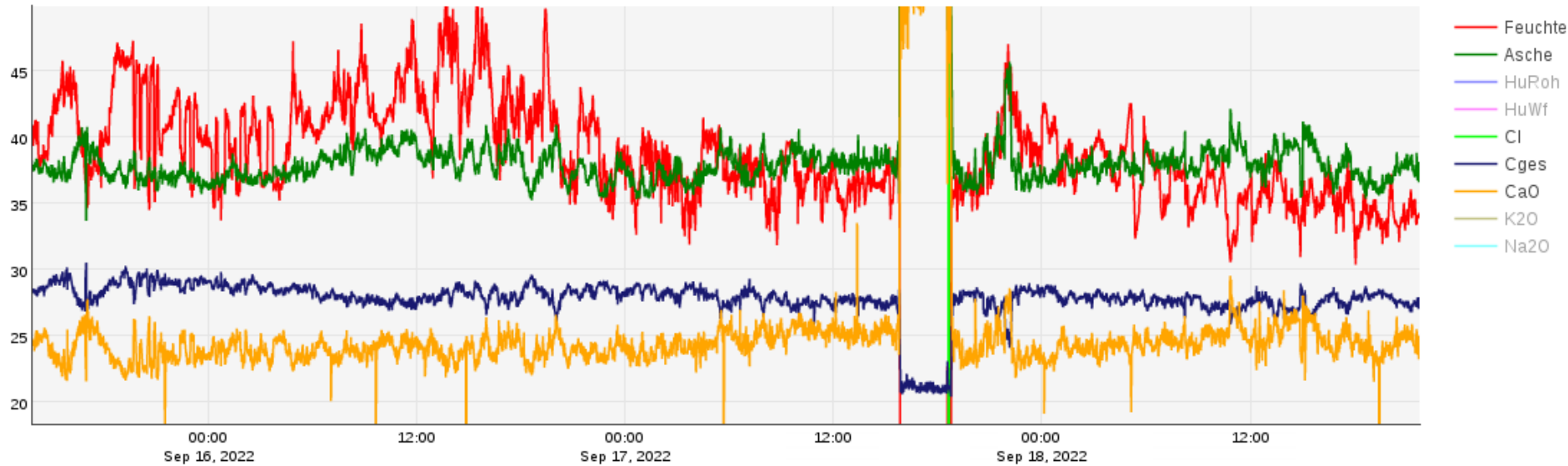
| | | Min | Max | Min | Max | ± absolut 1 Sigma | ± % deviation* | Target range |
|------------------------------------|----------|-------------------------------------|------------|---------------------------|------------|------------------------------|---------------------------|-------------------------|
| | | Measurement range (for calibration) | | Typical measurement range | | Performance guarantee | | ± 1 Sigma |
| Chlor, ges. | % | 0,00 | 1,50 | 0,00 | 0,60 | 0,06 | 10,0 | 0,04 |
| Lower heating value _{raw} | kJ/kg OS | 1.800 | 10.000 | 2.500 | 6.500 | 360 | 9,0 | 250 |
| Dry mass | % | 40,0 | 80,0 | 55 | 75 | 2,0 | 10,0 | 1,5 |
| Ash 950°C | % | 25,0 | 55,0 | 25 | 50 | 2,0 | 8,0 | 1,5 |
| C(total) | % | 20,0 | 40,0 | 20 | 40 | 1,5 | 8,0 | 1,5 |
| CaO | % | 10,0 | 50,0 | 15 | 45 | 3,0 | 10,0 | |
| Potassium | mg/kg | 0 | 6000 | 300 | 5.00 | 250 | 5,0 | 200 |
| Sodium | mg/kg | 0 | 3000 | 500 | 2.60 | 250 | 12,0 | |



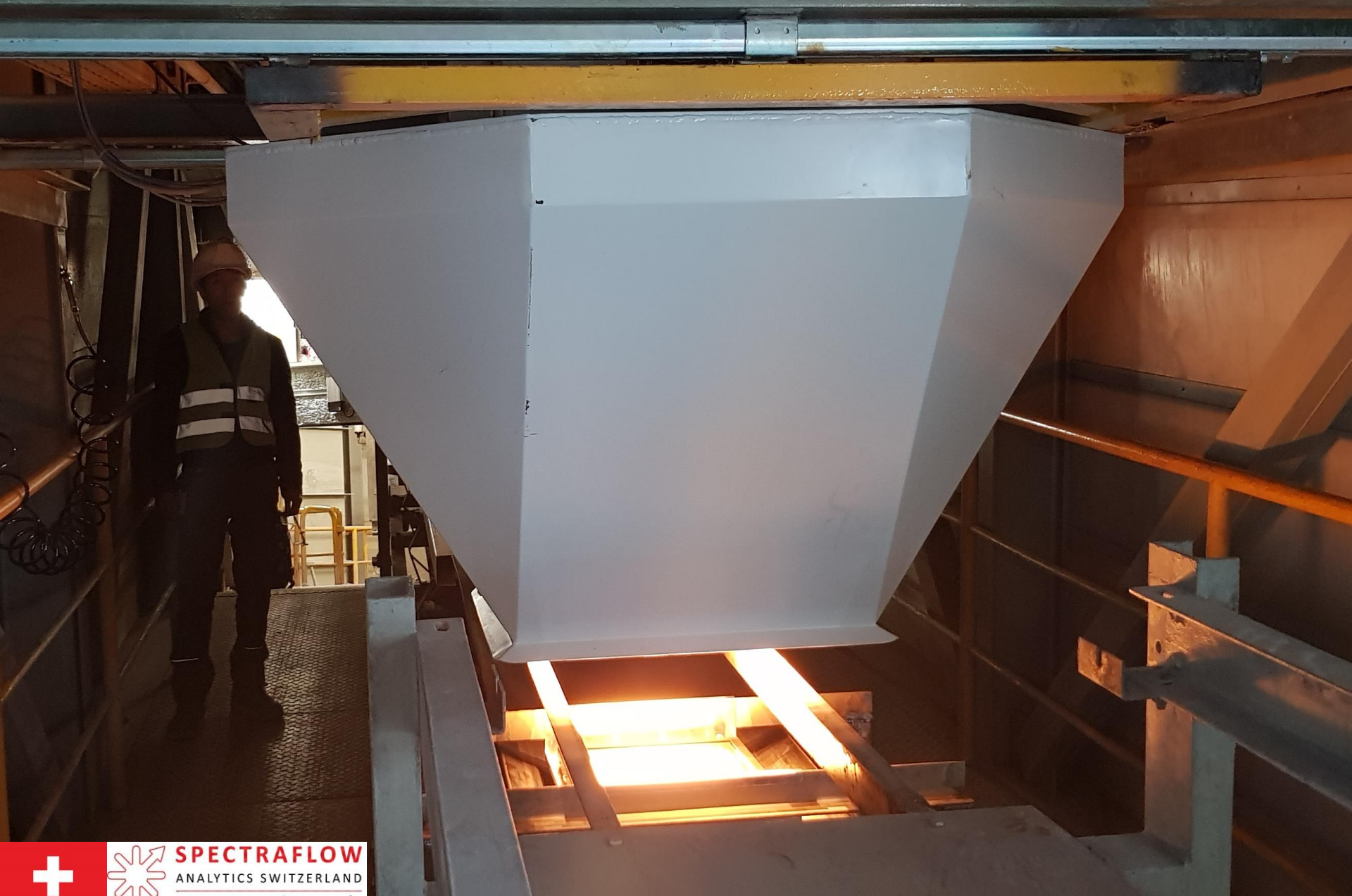
SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FULES @ UPM



SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FUELS @ UPM



SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FUELS @ UPM



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SPECTRAFLOW CASE STUDY 1 – ALTERNATIVE FUELS @ UPM



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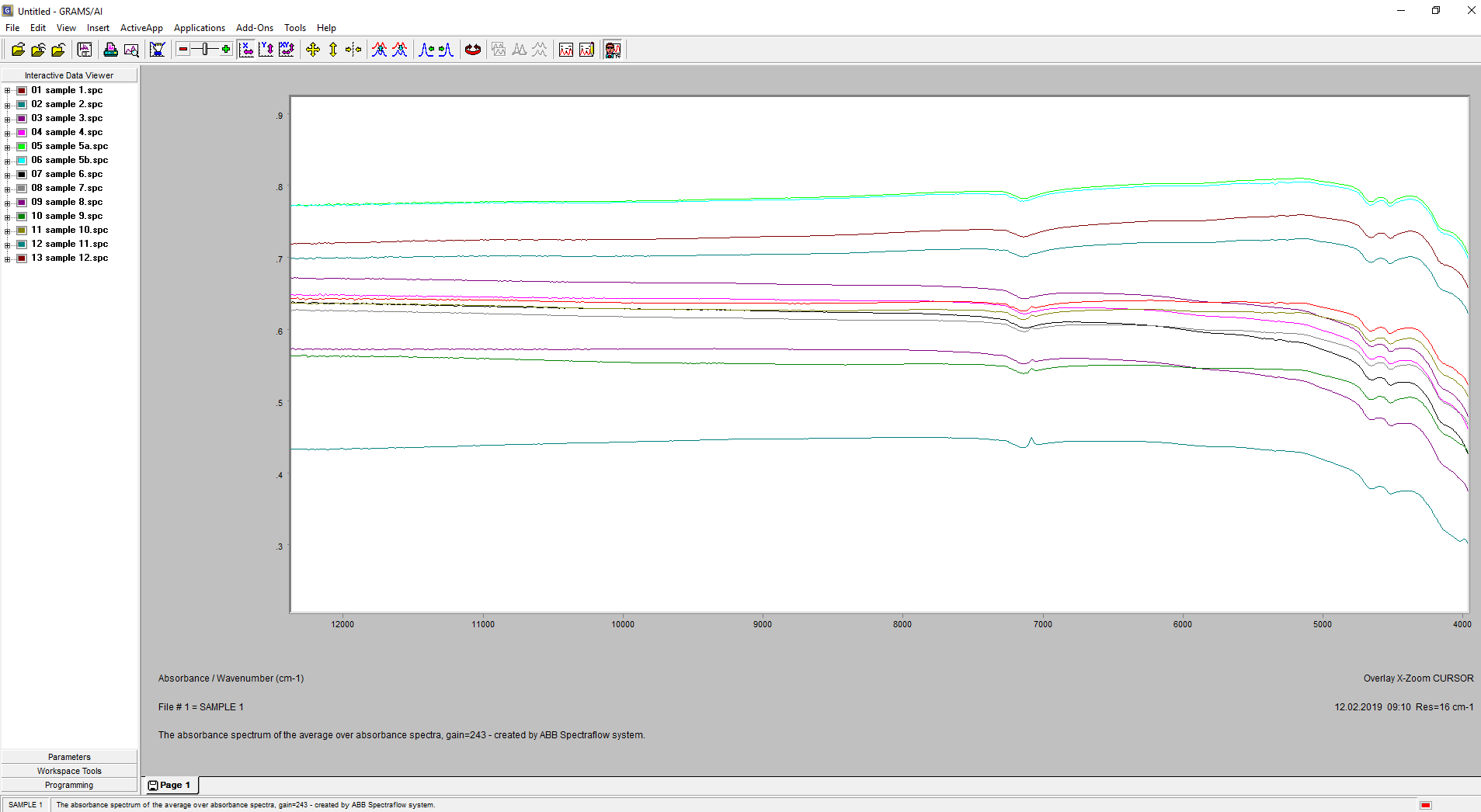
- plant was using fly ash as a flux in 2018 for their gasification project
- Question was the mineral content of the ash to be able to automate the calculation of slag & viscosity in FactSage
- Amorphous vs. Crystalline content?
- CaO vs. Anhydrite / Gehlenite / Anorthite / Calcite



SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client

| Component and Formula | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh | FlyAsh |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|---|----------------------|----------------------|--------------|--------------|
| | Sample 6 | Sample 8 | Sample 7 | Sample 4 | Sample 3 | Sample 2 | Sample 5 | Sample 1 | Sample 10 | Sample 9 | Sample 11 | Sample 12 |
| | F-IC (Indonesian) | F-IC (Indonesian) | F-IC (Indonesian) | F-IC (Indonesian) | F-IC (Indonesian) | F-IC (Indonesian) | F-SA (S. African) | F-SA MV-C (S. African MV Catherina) | F-SA (S. African) | F-SA (S. African) | F-CCPP-AHP | CCPP-AHP |
| | 17/09/2018 | 14/09/2018 | 10.09.2018 | 07.09.2018 | 03.09.2018 | 31/08/2018 | 24/09/2018 | 27/08/2018 | 24/08/2018 | 17/08/2018 | 24/09/2018 | 20/08/2018 |
| Amorphous Fraction (%) | 52.53 | 46.82 | 29.13 | 51.12 | 25 | 21.69 | 44.45 | 29.58 | 37.28 | 10.43 | 32.49 | 41.25 |
| Crystalline Fraction (Total %) | 47.47 | 53.18 | 70.87 | 48.88 | 75 | 78.31 | 55.55 | 70.42 | 62.72 | 89.57 | 67.51 | 58.75 |
| Iron Silicate (Fe₇SiO₁₀) | 1.51 | 3.45 | 3.35 | 2.78 | 2.43 | 2.31 | 2.98 | 2.78 | 2.58 | 1.58 | 2.12 | 1.85 |
| Lime (CaO) | 0.81 | 1.48 | 5.89 | 1.25 | 4.86 | 8.13 | 4.16 | 5.68 | 6.04 | 11.26 | 3.15 | 2.63 |
| Quartz (SiO ₂) | 17.28 | 19.11 | 23.76 | 17.95 | 27.38 | 24.63 | 14.59 | 18.67 | 14.94 | 21.17 | 26.72 | 23.2 |
| Calcite (CaCO ₃) | 1.5 | 1.18 | 1.18 | 1.5 | 2.73 | 1.19 | - | - | - | 17.71 | - | - |
| Nepheline (Na _{7.11} Al _{7.2} Si _{8.8} O ₃₂) | 3.46 | 3.5 | 0.86 | 1.9 | 5.3 | 2.12 | 0.88 | 1.15 | 0.82 | 3.16 | 3.18 | 3.31 |
| Mullite (Al _{4.64} Si _{1.36} O _{9.68}) | 2.86 | 4.55 | 6.57 | 2.6 | 6.52 | 9.27 | 6.56 | 7.78 | 5.37 | 5.56 | 5.93 | 6.72 |
| Hematite (Fe ₂ O ₃) | 2.62 | 2.3 | 3.57 | 2.51 | 3.19 | 3.21 | 3.02 | 3.78 | 3.39 | 3.56 | 3.27 | 3.03 |
| Titanium Oxide (TiO ₂) | 1.78 | 1.48 | 3.43 | 1.63 | 3.62 | 5.72 | 2.04 | 1.89 | 1.82 | 1.89 | 1.58 | 1.33 |
| Phosphide Oxide (P ₂ O ₅) | 2.13 | 0.6 | 1.9 | 2.47 | 1.78 | 7.17 | - | - | - | - | - | - |
| Anhydrite (CaSO ₄) | 1.11 | 1.57 | 6.21 | 1.94 | 4.58 | 7.9 | 4.23 | 6.51 | 6.4 | 6.12 | 3.99 | 3.84 |
| Anorthite (Na _{0.14} Ca _{0.85} Al _{1.83} Si _{2.16} O ₈) | 4.06 | 5.85 | 6.12 | 5.75 | 7.32 | 7.25 | 8.33 | 7.36 | 8.98 | 5.44 | 6.95 | 6.15 |
| Sodium Silicon Oxide (Na₆Si₈O₁₉) | 4.61 | 4.19 | 3.33 | 2.63 | 2.11 | - | - | - | - | - | - | - |
| Gehlenite (Ca₂Al₂SiO₇) | 3.79 | 3.92 | 2.88 | 3.99 | 5.3 | 3.11 | 1.93 | 3.13 | 3.15 | 3.03 | 1.89 | 0.61 |
| Periclase (MgO) | - | - | 0.59 | - | 1.16 | 0.91 | 1.99 | 2.06 | 1.86 | 2.15 | 1.31 | 1.67 |
| Potassium Oxide (K₂O) | - | - | 1.16 | - | 0.94 | 1.53 | 2.15 | 3.95 | 3.48 | 3.27 | 2.91 | 2.65 |
| Potassium Sodium Oxide (KNaO) | - | - | - | - | - | - | 0.55 | 1.11 | 0.98 | - | - | - |
| Calcite (Mg) | - | - | - | - | - | - | 2.18 | 1.74 | 1.63 | 2.39 | 2.51 | 1.23 |
| Portlandite Ca(OH)₂ | - | - | - | - | - | - | - | - | 1.27 | 1.27 | 2 | 0.53 |

SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client



SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client

| Component and Formula | Amorphous Fraction (%) | Crystalline Fraction (%) | Lime (CaO) | Anhydrite (CaSO4) |
|-----------------------------------|------------------------|--------------------------|------------|-------------------|
| min | 21.69 | 47.47 | 0.81 | 1.11 |
| max | 52.53 | 78.31 | 8.13 | 7.90 |
| Range | 30.84 | 30.84 | 7.32 | 6.79 |
| Calibration R ² | 0.95 | 0.94 | 0.98 | 0.99 |
| Test RMSEP | 2.30 | 2.10 | 0.69 | 0.35 |
| % RMSEP | 7.4 | 6.8 | 9.4 | 5.1 |
| Prediction | | | | |
| Sample 1 (Lab %) | 29.58 | 70.42 | 5.68 | 6.51 |
| <i>Sample 1 - SFA Prediction</i> | 32.85 | 68.15 | 6.59 | 7.02 |
| <i>delta in % of range</i> | 0.11 | 0.07 | 0.12 | 0.08 |
| <i>delta absolut</i> | 3.27 | 2.27 | 0.91 | 0.51 |
| Sample 5b | 44.45 | 55.55 | 4.16 | 4.23 |
| <i>Sample 5b - SFA Prediction</i> | 46.00 | 53.81 | 4.31 | 4.51 |
| <i>delta in % of range</i> | 0.05 | 0.06 | 0.02 | 0.04 |
| <i>delta absolut</i> | 1.55 | 1.74 | 0.15 | 0.28 |

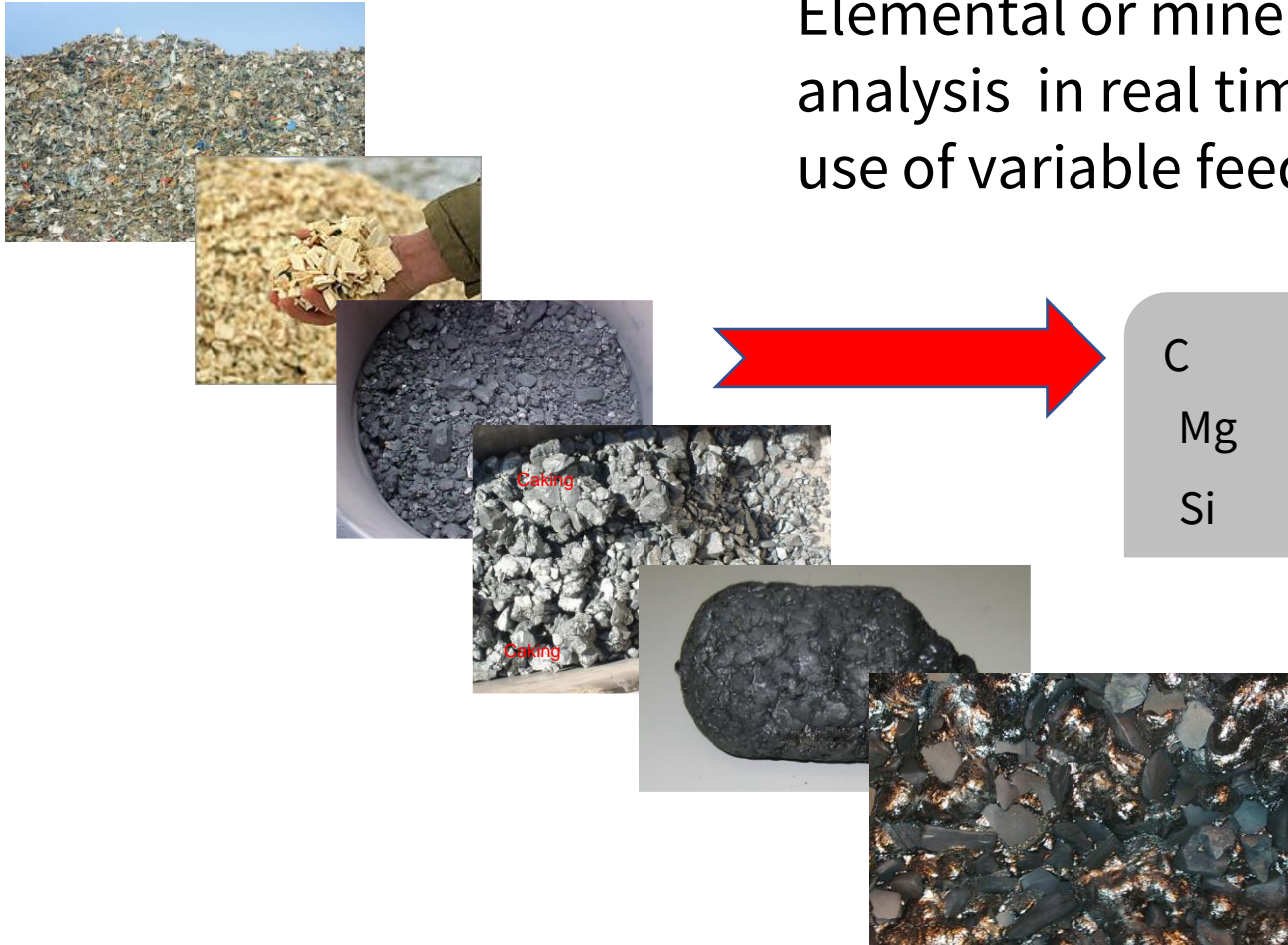


SPECTRAFLOW CASE STUDY 2 – Minerals in Fly Ash @ India client

| Component and Formula | Anorthite (Na _{0.14} Ca _{0.85} Al _{1.83} Si _{2.16} O ₈) | Gehlenite (Ca ₂ Al ₂ SiO ₇) | Calcite combined (CaCO ₃ & Mg) | Calcite (CaCO ₃) | Calcite (Mg) |
|------------------------------|---|--|---|---------------------------------|-----------------|
| min | 4.06 | 0.61 | 1.18 | 1.18 | 1.23 |
| max | 8.98 | 5.30 | 2.73 | 2.73 | 2.51 |
| Range | 4.92 | 4.69 | 1.55 | 1.55 | 1.28 |
| Calibration R ² | 0.96 | 0.99 | 0.92 | 0.98 | 0.98 |
| Test RMSEP | 0.98 | 0.17 | 0.22 | 0.06 | 0.06 |
| % RMSEP | 20 | 3.6 | 14.6 | 3.8 | 4.7 |
| Prediction | | | | s. 2 | |
| Sample 1 | 7.36 | 3.13 | 1.74 | 1.19 | 1.74 |
| <i>Sample 1 - SFA Pred.</i> | 8.53 | 3.17 | 1.80 | 1.21 | 1.73 |
| <i>delta in % of range</i> | 0.24 | 0.01 | 0.04 | 0.01 | 0.01 |
| <i>delta absolut</i> | 1.17 | 0.04 | 0.06 | 0.02 | 0.01 |
| | | | | s. 6 | |
| Sample 5b | 8.33 | 1.93 | 2.18 | 1.50 | 2.18 |
| <i>Sample 5b - SFA Pred.</i> | 7.59 | 2.11 | 1.95 | 1.51 | 2.16 |
| <i>delta in % of range</i> | 0.15 | 0.04 | 0.15 | 0.01 | 0.02 |
| <i>delta absolut</i> | 0.74 | 0.18 | 0.23 | 0.01 | 0.02 |

FROM ANALYTICS TO ACTIVE PROCESS CONTROL

Elemental or mineral phase analysis in real time allowing the use of variable feed stock



| | | | | | |
|----|----|----|----|----|---|
| C | | Al | | | |
| | S | | Cr | O | V |
| Mg | | | | | |
| Si | Fe | N | | Ca | H |

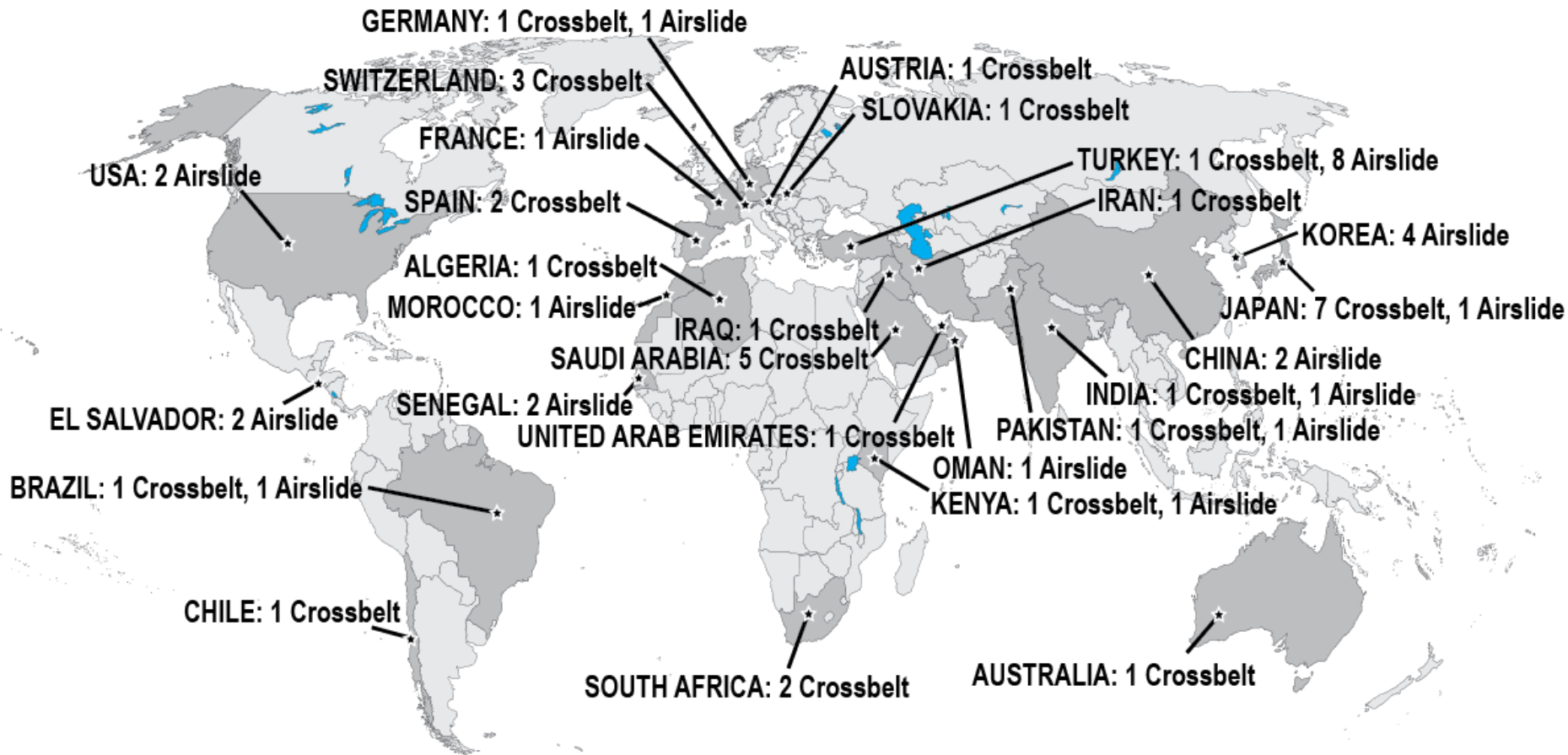


FROM ANALYTICS TO ACTIVE PROCESS CONTROL

- Elemental or mineral phase analysis in real time allowing the use of variable feed stock
- Ability to reject, recirculate or flux the feed
- Ability to adjust process parameters at the gasifier in real time, e.g. with the model in FactSage



INSTALLED BASE THROUGH VARIOUS INDUSTRIES



- NIR is a proven industrial real time analytical method for minerals and organics
- NIR is sensitive to organics, minerals and moisture
- Real time analysis opens the opportunity to
 - Prepare stable feed
 - Balance variations with fluxes or by mixing feeds
 - Enable active real time process control for combustion or gasification e.g. by use of FactSage



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THANK YOU VERY MUCH FOR YOUR ATTENTION



NA MEASUREMENT IN PPM RANGE @EGA RECYCLE ANODES

