Greetings from Division Director

Welcome to the fourth edition of the Mining and Metals Division Newsletter.

Some say we should not overthink things too much and that innovation happens when humans take a genuine interest in their job or each other. There is some truth to this, but I believe there is more to it. The industry is changing and with this should our approach. Teams are more agile and there is ever more data at hand for us to turn into new ideas. Cultures are changing as previous layered and hierarchical structures are in the way of giving creativity a chance. Technology provides a helping hand as availability and affordability of computing power and data storage is at the lowest cost point in history. Then there are many new clever sensors and local cyber physical systems and their applications that are excelling at hyper speed covering ever smarter use-cases capturing value.

I hope you are getting the point – we live in a time of great opportunity. But how can ISA.org capture some of this positive energy and reinvent itself? This has been a challenge, but our leadership is relentless and up for it with your support.

Solving the big and complex issues through Digital Leadership

There is nothing more powerful than giving people free range at solving big issues that they genuinely care about. It does not matter if this is at their own pit or plant floor or when solving greater things for our society. It is interesting to watch when teams meet and combine their ideas to challenge the status quo. From a distance one could say that there is great overlap how point solutions get applied to common problems and processes. Solutions often start to address a single issue, but wider solutions take more time and money to produce. This is the reason that typical solutions don’t integrate and interoperate too well out of the box. Most Enterprise players in the Metals and Mining market invested in point solutions and have addressed their integration as an afterthought. As a result, there is currently a choice of integrating alternative “Best of Breed” or BoB solutions or for miners to purchase an integrated “Enterprise Solution”. A typical Enterprise Solution has already been integrated out of the box for its core modules but when compared with BoB solutions that are frankly missing needed functionality to support very specific but key processes. It is the commodity specific software that adds real value for mining companies and currently the reason there are still so many software players in this market.
Finally, there is the goal of the ultimate and “Connected Enterprise” of Industry 4.0 that ISA-95 is addressing with work and data flow in mind to address key business and operations processes. We are not saying that all functionality could be satisfied but we are saying that most core data relevant for each of the core processes of a mining operation is considered and addressed. If we target Planning, Scheduling, Production, Product Quality or Energy Control it all has been considered with inputs and intelligence from across many industries.

**Connected Enterprise out of the box or reinvent the wheel?**

ISA standards provide a great starting point, a good bench mark or reference point when it comes to designing a digital mining enterprise. This is also the reason that so much support for the ISA standards and organization exists. Knowledge and experience contained in the ISA standards is often greatly underestimated, not fully leveraged nor widely communicated.

Most of us would have seen it is natural for people to want to reinvent the wheel and create solutions from scratch as part of their own learning process. Also, we know that adopting programing-code from others is just not as satisfying as creating your own. Therefore, it takes great digital leadership to redirect the energy of design and development teams and ask them to leverage available standards as a foundation. When they do they to come to greater heights and increased integrated functionality “per-dollar-invested” as a result.

Teams that do this have proven to create more holistic interconnected and open solutions that cover greater parts of the value chain. That is exactly what mining companies should be looking for when aiming to deliver on the potential of what we know as Industry 4.0. In this space we know that the connected enterprise is only as good as the sum of its parts and the main reason for still so many complex integration and migration projects today.

Some organization that leverages ISA standards is the Open Group Open Process Automation forum (OPAF) which is focused on developing a standards-based, open, secure, interoperable process control architecture. With combined intelligence from the ISA standards and the Open Group Enterprise Architecture standards (like TOGAF) they aim to develop vendor-neutral technology standards and certifications for brownfield organizations. Please see: [ISA & The Open Group cooperation](#).

**Beyond the basics**

Some software and technology vendors would complain that for them this direction of adopting standards is not great. You hear them say this results in "vendor neutral and commoditized solutions" but is even more a reason to leave these nay-sayers behind when it comes to Industry 4.0. The value is not in providing the basics any more. Instead it is about what vendors can provide their customers beyond providing fundamental connectivity. With autonomous mining gaining traction, it is about increased levels of automation, operator advisory systems and even provision of Artificial Intelligence. All while addressing automated processes safely and securely.

Addressing a larger enterprise requires both local and central intelligence that we still can’t take for granted currently. Platform thinking, and edge computing is still relatively new, and the mining industry just does not have the volume promise for vendors to pre-invest and engineer-out all the industry and commodity specific issues. Also, we might hear about cyber exposures in the news every day, but we can’t just sit back and wait for cyber best practices to be offered in typical mining solutions as many vendors still don’t consider this in their original designs. If they do, they often have not considered relevant scenarios that will appear when connecting their solution to new technologies part of the wider enterprise in an autonomous environment.

**Accelerate with caution**

If you plan to design quickly this could capture some additional early value. Be aware though of the risks when you “borrow or inherit” some ready building blocks into your Industrial Internet of Things (IIoT) solutions. When leveraging functionality like Active Directory or maybe look to leverage Program Libraries from known typical software vendors, you are taking some risks. These and similar risks would show in some of the initial digital twin solutions that this market has seen. We suggest you still need to consider the impact of these choices, how to secure the functionality for undesired interventions and therefore perform significant integrated testing and hardening of these integrated solutions. This will limit real risks to your operation, improve the safety of your staff, the environment and as a result ultimately protects value for your shareholders.
We believe it is therefore good for mining companies to keep some of this important knowledge in house if it wasn’t just for defining at least the prerequisites. When you are at least involved in designing and accepting your solution environment you would know typical weak spots and how to monitor performance in real time. This is very helpful when unexpectedly things would run out of control in production or when increased automation is desired and integration points and with this the Attack-Surface increases.

It is good to see that executive buyers and end-clients rightly are getting more digital savvy and vocal when aiming for ultimate productivity through connecting elements of their enterprise. It is also good they are supported by a mix of industry consultants just because of the simple fact that these consultants have seen more scenarios and architectures operate under all types of conditions.

For the entrepreneurs under us, we also believe clients definitely still are after the additional and differentiated value that software and hardware vendors can provide. Smart clients know this provides them with a competitive edge. It would be good if we will see them getting better at prescribing some of these fundamentals to move our industry ahead on the maturity curve - faster.

Continued investment in our standards
We want the buyers to know that the “language” provided by the ISA-95 and ISA-99/IEC 62443 standards has never been closer aligned to the specific use cases required to support the metals and mining industry. This has been possible by continued investment and intelligence by some of the world largest organizations and some great industry consultants. We know through the ISA channels that they went to great lengths discussing and aligning around the specifics to mine planning, scheduling, production accounting and assay management considering Industry 4.0 thinking and autonomous execution.

This is why we now are wanting more end-users and vendors to get involved to start the wider adoption and fine tuning that will be needed to improve the various productivity factors and complexities that makes mining so unique and a great place to be for us business operators, technicians, multi discipline engineers, metallurgists and geologists.

We will rely on your experience, what you have to say and invite you to help us articulate the value and how it best can be applied into your specific challenges for the bigger good of our industry. We believe the path to Industry 4.0 will be easier when you educate your leadership, train your IT/OT and Enterprise Architecture specialists and provide them with a shared vision and a path that considers ISA standards as part of your digital enterprise strategy.

Our division mostly depends on volunteers and we are looking for more believers who see that decision making and automation with ISA is just more efficient and can help transform our industry ready to compete in the commodity market tomorrow, starting today.

Thanks for your support,

Bas Mutsaers – Director ISA Metals and Mining Division

PS: Please reach out to us if you want to get involved. We are an inclusive bunch but are working to be more diverse in our membership, commissions and working groups. Therefore, if you have a Point of View or frustrations we can address please volunteer independent of your level of experience.

Our Volunteer Leaders:

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WebMaster....................... Ari Supomo
Section-Division Liaison....... Carlos Mandolesi
Committee Members .......... Sandeep Vysvaraiu
                                      Michael Hughes
                                      David Howat
                                      Harry Sowieja
                                      Robert Zwick
Leader Biographies

**Bas Mutsaers** is an innovative, results driven professional with extensive experience in setting and executing strategy, leading various high performance teams in the areas of consulting, engineering and software development across the Natural Resources, Energy (up- mid and downstream), and Utilities industries. This has been achieved in APAC (ANZ Region), India and Europe. Over 15 years leveraging ISA standards like ISA95/ISA99 with a strong global network and deep experience analysing, selling, designing, building, testing and deploying innovative industry-specific solutions. Leader of many Global complex migration and transformation projects and pursuits with strong solutions, systems and business process capability. Leveraged ISA standards across domains of ERP, EAM, MES, and Industrial Automation achieving IT/OT convergence by leveraging the ever-growing data of Sensors, People and Technology across the entire value chain and applying it in BI and Analytics solutions.

**Donald J Root, PE** is a licensed professional electrical engineer with 33 years of experience in electrical power & control systems, mechanical design, and project management. He pioneered the use of PLCs in several industrial applications and is fully knowledgeable in US and international electrical codes that apply to environmentally-rated industrial locations areas. He is the author of magazine articles and book sections on the use of control systems and has been a guest instructor at Kansas State University. Don has seven years of P&L experience in a small high technology company and international experience executing projects in the People’s Republic of China, Thailand, Indonesia, The Philippines, Romania, Poland, Ecuador, Puerto Rico, and the Caribbean.

**Ari Supomo** has been in the process automation in the mining industry for all his professional life. Says Ari, “I joined ISA so that I can stay informed with the automation advancement. In addition, I can learn and apply automation best practices and standards from ISA to our mining sites. I believe there are great opportunities for the mining industry and companies to work and partner with ISA. My goal for the division is to improve the communication, participation, interaction and collaboration between ISA and mining society/community.”

**Carlos Mandolesi** is the owner of Sigmma Automation located in Brazil, with 24+ years’ experience in industrial automation and networks and now with a strong focus in Industrial Internet of Things. Experienced in large projects in mining, metals, oil & gas and biofuels including customers like VALE, Anglo American, Samarco and Petrobras. Carlos is ISA District 4 (South America) Vice President and was elected to be a member of ISA Executive Board.

**Robert (Rob) Zwick, P.Eng.** is President of Automan Controls Inc.; a provider of OT services. Rob has over 30 years of management and engineering experience related to operations technology, industrial control systems, automation technology, high technology, and advanced process control applications.
Featured Technical Article

An NPV Justification to Implement Advanced Process Control (APC) for Ore Communion
By Robert Zwick, M.A.Sc., P.Eng.

Background
Ore comminution is reduction of solid materials to a target particle size through crushing, grinding and screening. This is an energy-intensive process that plays a central role for production at a mining facility. Not only must traditional Operator objectives be met such as maximizing production and/or product quality, but factors have now been introduced to the modern-day Operator. For instance, decisions around control set point changes now take into consideration minimizing energy consumption, minimizing water consumption, minimizing other consumables (reagents, grinding media, etc.), minimizing environmental impact and others. And all the while, attempting to maximize the plant profitability. Advanced Process Control is a general term used to describe process control software that can simultaneously control multiple setpoints of the entire ore comminution process. This paper suggests using the Net Present Value (NPV) as an ideal method to justify the installation and maintenance of Advanced Process Control software at an ore processing facility.

Reported APC Successes in Mining and Metals (M&M)
For the Mining and Metals industry, APC’s have been successfully implemented with documented benefits of guaranteed production improvement. Depending on the project size and complexity, installed costs of APC projects range between $200k – $500k with returns on investment of 1 year or less. In the M&M industry these kinds of ROI’s exist for applications such as:

- SAG and ball mill grinding
- Washing and finishing circuits
- Flotation circuits
- Roasters and other pyrometallurgical processes
- High-Pressure leach and other hydrometallurgical processes
- Cement processing and lime kilns

Typical APC projects can take between 6 – 10 months to complete and commission. APC and optimization can improve operating profit margins in 4 ways:

i. Higher production rates with documented improvements typically from 3% to 5% – by pushing against constraints.
ii. Lower raw material, energy usage per unit of product and emissions with documented improvements typically from 3% to 5% – by pushing against constraints.
iii. Lower product losses & rework – by reducing quality variability with documented improvements typically from 10% to 20%.
iv. Improved production stability and continuity by reducing production variability
v. Improved maintenance costs such as reduced refractory consumption with documented improvements typically from 10% to 25%.

How an APC Technology Project can be Justified
A technology project has no value unless it can drive profits for the Mining and Metals operation. Advanced Process Control (APC) is a software technology that can play a dominant role in driving the company bottom line. A previous article in the 2017 Fall ISA newsletter discussed “Applications and Benefits of Advanced Process Control in M&M”. Refer to that article to get a good background on what APC is all about. In this article, we will explore APC justification further. The technology has increasingly become more “mainstream” not only because of the recognized and fully-established benefits, but because costs have decreased due to improved control system OPC connectivity, lower APC software licensing costs and easier “off-the-shelf” implementations that have been witnessed and experienced throughout the industry.

Approach in Justifying an APC Project
Justifying APC is done by establishing process variability of key process variables (CV’s) for the Manipulated Variables (MV’s). And then an estimate is made on the reduction in key CV variability APC would achieve – it’s typically a reduction in one-half to one standard deviation. Establishment of Disturbance Variables (DV’s) or feedforward variables, along with Process Constraint variables (AV’s), will determine the limits on what would be the potential change in the new setpoint.

Justification is developed by predicting the potential process variability reduction and then the corresponding
potential change in setpoint based on the constraint limits. This is shown in Figure 1:

This figure shows that:

- Random influences create a normal CV variation
- Advanced control can reduce the standard deviation of a performance variable typically by up to half a standard deviation
- This allows the set point to move an amount equal to the reduction in initial standard deviation or to the constraint limit and will yield economic benefits with no degradation of product quality
- Based on a newly established set point, an economic justification can be made to project expected benefits.

Establishing economic benefits for the improved set-point typically is associated with improved production by operating closer to the constraint limits, or with APC implementations, closer to optimum values through additional constraints and optimization. As per traditional APC or closer to overall value when adding new constraints. The reduction in variability also improves specific energy consumption along with product quality improvements. Most justification ignores quality improvements because it is a difficult value to establish objectively. But production improvements and specific energy reduction are well-established, and justification is then done with either a Return On Investment (ROI) calculation or a payback calculation. This is the most common approach for justifying an APC project.

Having either a hard (ie; software implemented with control software) or soft (operator advisement) avoidance of running into a constraint limit, improves equipment Mean Time Between Failure (MTBF). There is a direct impact on MTBF when key equipment is operated and not exceeded over its design constraints. But improvements to MTBF typically takes over a year or longer to be achieved. Also, to measure the payback often takes time beyond 6-12 months. What does an increase in MTBF have for an impact on profitability? How can an improvement in MTBF be captured over a multi-year time horizon when justifying a project?

MTBF improvements allow for an increase in available time for production during a given time period. This translates directly to an increase in Overall Equipment Effectiveness (OEE) and have a substantial impact on profitability. One approach to evaluation justification in OEE improvements is by using the Net Present Value (NPV) approach and can nicely take into account multi-year time horizons. This approach is reviewed with an example related to an APC investment for a SAG Mill.

Increasing the MTBF of a SAG Mill

Semi-autonomous Grinding Mill’s (SAG Mills) are the largest capital-cost machine at a mine, the largest energy consumer and most typically is the production facility bottleneck. If the SAG Mill is running poorly or is down, plant production is directly affected. APC installations for a typical SAG Mill have the following documented improvements:

- Increased throughput 2 - 5%
- Reduced electricity consumption 2 - 5%
- Reduced quality variability 10 - 20%
- Reduced liner consumption 10 - 25%

Throughput and specific energy improvements are well documented for APC justification on SAG Mills. Improved quality has also been claimed, though that proves harder to use for justification purposes. But an improvement in liner consumption directly affects the MTBF or when a SAG mill needs to be shut down for a liner replacement. Industrial equipment like a SAG Mill will always have a longer runtime when it’s not operating over design constraint limits. Typical APC constraints (AV’s) to improve SAG Mill MTBF include:

- Maximum feed rate
- Recycle tonnage rate
- Cyclone feed density (maximum % solids)
- Ball Mill loading (minimum amps)
- SAG Mill motor protection (maximum amps)
- SAG Mill load or bearing pressures (Feed and Discharge) i.e. prevent classic overload
- Product Grind Size/Liberation maximum (microns)
- Hydro-cyclone feed pressure, flow rate, motor current

The problem with establishing the impact of reduced liner consumption is that this improvement from an APC install may not be realized in the first year; nor the second. If it’s a 25% liner lifetime improvement, that could potentially not be recognized until the 5th year of an APC installation, if the existing liner replacement frequency is 12 months. How important of an issue is MTBF to establish the economic justification? Let’s look at a financial model of a mill to see and use an NPV analysis.

Financial Model of a Mill
A simplified financial model of a mine mill was created with the following assumptions:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Base Case</th>
<th>APC Install Yr. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating days</td>
<td></td>
<td>344</td>
<td>344</td>
</tr>
<tr>
<td>Throughput rate</td>
<td>t/h</td>
<td>1500</td>
<td>1530</td>
</tr>
<tr>
<td>Power cost</td>
<td>$/kWh</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Grinding media cost ($ per tonne of media)</td>
<td>$/t</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>SAG mill liner replacement per year</td>
<td>$ M</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Grinding media consumption SAG mill</td>
<td>kg/t</td>
<td>0.4</td>
<td>0.38</td>
</tr>
<tr>
<td>Grinding media consumption ball mill</td>
<td>kg/t</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Total media consumption</td>
<td>kg/t</td>
<td>0.9</td>
<td>0.88</td>
</tr>
<tr>
<td>SAG mill liner cost</td>
<td>$/t</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td>Power</td>
<td>$/t</td>
<td>1.39</td>
<td>1.3622</td>
</tr>
<tr>
<td>Grinding media</td>
<td>$/t</td>
<td>1.08</td>
<td>1.0584</td>
</tr>
</tbody>
</table>

The further assumption that there is an improvement to the APC of the following:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Production improvement</td>
<td>2%</td>
</tr>
<tr>
<td>Energy efficiency improvement</td>
<td>2%</td>
</tr>
<tr>
<td>SAG media cost saving improvement</td>
<td>2%</td>
</tr>
</tbody>
</table>

And with the following business scenario (required for this simple mill financial model, plus the NPV analysis):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power as percentage of total cost of manufacturing (assumed)</td>
<td>35%</td>
</tr>
<tr>
<td>Mill Profit margin</td>
<td>15%</td>
</tr>
<tr>
<td>Return on investment</td>
<td>20%</td>
</tr>
<tr>
<td>Year 5 realization of extended liner replacement</td>
<td>$1,500,000</td>
</tr>
</tbody>
</table>

NPV Analysis
Net present value (NPV) is determined by calculating the costs (negative cash flows) and benefits (positive cash flows) for each period of an investment. NPV can be a useful analysis approach in the mining industry because of a known mine lifetime, which defines the period N, or the period of time N one wants to look at the investment.

\[
NPV (i, N) = -C_0 + \sum_{i=1}^{N} \frac{C_i}{(1+r)^i}
\]

- \(r\) = discount rate – can be where you can better put your money, or risk of your investment
- \(C_i\) = Cash inflow, for a given time \(i\)
- \(C_0\) = Cash outflow at the onset

The cash flows in net present value analysis are discounted for two main reasons, (1) to adjust for the risk of an investment opportunity, and (2) to account for the time value of money. One of the nice features of an NPV analysis, is that if the investment risk is high (like a development project), one can increase the discount rate \(r\) to further discount the expected cash flow.

NPV analysis can also capture investment opportunities related to OEE improvements, particularly projects that are multi-year. The following values were used in the financial model for this APC project example:

- Specific energy decrease of 2%
- Production increase of 2%
• Media cost savings of 2%
• Improved MTBF liner replacement of 25% (because of operating within constraints)
• Improved quality is not considered for simplification, but does exist
• Capital project of $500,000
• Liner replacement cost of $1,500,000

Results of the NPV Analysis
Even if there is a heavily-discounted project (maybe because it’s considered “high risk”) where in this example the discount rate was considered to be at 20%, we can still see how big of an impact on MTBF has with the graphical results shown in Figure 2 below:

![NPV Analysis over 5 years](image)

The orange line is the cumulative benefits and the bars are the cash flow for each year of the project. Where the orange line crosses over the horizontal axis speaks to a payback of something like half a year. So, an NPV analysis also establishes the expected payback for a project. But what this analysis also shows is the benefit of an APC project where an increased MTBF can potentially far outweigh any cash flow benefits of improved production or specific energy consumption! Even if this improvement in MTBF is a benefit not fully realized for 5 years!

APC’s are a great opportunity for the M&M Industry
In summary, APC’s are becoming increasingly commonplace with the Mining and Metals industry. This is due to lower capital costs for these types of projects, availability of capital, relatively fast installation times of less than six months (and without plant interruption), along with recognized and proven increase to overall plant profitability. Most the major automation companies have proven APC solutions, and most are built on similar technology platforms. APC applications are no longer development projects and now can be characterized as using well-established control engineering methodology. In summary

• APC for comminution is becoming an increasingly mainstream technology
• NPV model analysis shown in this example demonstrates a significant cash inflow at ~ Year 5 because of the 25% improvement in MTBF starting in Year 1 (each year there’s a 3-month improvement over the base-case of a 12-month MTBF in liner wear)
• A simple payback or ROI model doesn’t properly capture economic benefits of technologies that improves MTBF – especially for multi-year projects

This simple example on a SAG Mill liner is directly applicable to other M&M opportunities for APC, high-value regulatory loops, process improvement projects or flow improvement effects on production downstream. All these have not been considered in this conservative business case. It has been shown for instance that furnace refractory life has been increased with APC installations due to not running the furnace above temperature design constraints.

This simple NPV analysis demonstrates that perhaps one of the biggest project justifications can be often be overlooked. Namely, the improvement in MTBF where a plant can run longer between scheduled shutdowns. And the use of APC’s is a perfectly viable approach to increase MTBF’s and significantly improve overall profitability.

Further references
1. ISA-95, Enterprise-Control System Integration. [https://www.isa.org/isa95/](https://www.isa.org/isa95/)
2. Overall Equipment Effectiveness. [https://www.oee.com/](https://www.oee.com/)
ISA Society News

It is hard to believe that we are moving into the 4th quarter of 2018, and our Annual Leadership Conference and Council of Society Delegates meeting is next month in Montreal, Canada. This has been a very dynamic year for ISA, and we have been focused on developing strategic initiatives that will lead the society into the future.

Collectively, we have been working toward a balanced budget for a number of years. This year, we are striving to land at break-even or better. The opportunity to balance the budget has come from top line growth and our continued efforts toward balancing efficiency with effectiveness.

There is an important motion coming before the Council of Society Delegates to raise our membership dues by USD10. The previous dues increase was three years ago.

Membership is a strategic priority for the organization. We understand that providing a unique value is important in serving and retaining our members.

We are committed to our four strategic programs—market sponsorship and awareness, member engagement, technical education and certification, also leadership and professional development—to further our vision and mission.

On behalf of the ISA Executive Board, we would sincerely appreciate your support of the dues increase as your commitment and investment in our strategic priorities. This contribution, along with top line growth and continued cost savings in many areas, will enable us to deliver strategic results for the continuous improvement of ISA.

Thank you for your continued support and contribution to ISA. We look forward to working together to advance ISA into the future—we have a lot of work to do and a lot of opportunities ahead of us.

Brian Curtis, ISA President

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About the ISA Mining/Metals Division

The Mining & Metals Industries Division (MMID) is one of ISA Technical Divisions. Its goal is to support and advance its members who are working and/or interested in the mining and metal industries. MMID focuses on leveraging automation functionality and technology solution to enhance mining processes and metal production.

Who is best served by this division? Professionals concerned with economically and environmentally sound practices as related to the extraction of metal ores, coal, cement, sand, gravel, and other minerals-and the handling, separation, processing, fabrication, related processes, and research and development to produce finished mineral or metal products. It also covers the Iron and Steel Making industry, Aluminum Processing and other light metals and the production and manufacturing of metals products.