Session 784

Macroergonomics: A Systems Approach to Achieve Safety Excellence

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Overview

Macroergonomics is concerned with the research, design, development, and application of the interface between organization, environment, human behavior and work systems. Traditional ergonomic interventions focus on physical workplace risk factors and may be limited by failure to address larger issues related to organizational issues in the work systems. This session will focus on concepts that will allow safety professionals to expand their knowledge and methods to address these broader organizational factors.

The presentation will discuss methods for safety professionals to:

- Use a systems approach to identify, understand and address the multiple factors that contribute to accident causation including physical, psychosocial and organizational issues.
- Develop methods to increase communication in the organization on key safety elements.
- Expand participation of the workforce in risk assessment and control.
- Integrate the use of team approaches to driving change in the organization.
- Monitor improvements in work systems through expanded, integrated measurement systems.

The presentation will summarize the Architecture of Safety Excellence (AOSE), which is a model for an organization to improve safety and ergonomics performance and can be used as a guide to applying macroergonomic principles. The AOSE model can establish the structure and provide the framework for action within the organization. This model is a systems approach that incorporates top down direction with bottom up ownership. Management Direction, Commitment and Leadership coupled with Employee Involvement and Ownership are the core drivers of success in the AOSE model. The model is based on using cross-functional teams to drive change in an organization. The cornerstones of the model are Risk Assessment, System Analysis, Integrated Solutions and Progress Measurement. These elements provide the team a plan for systematic identification, evaluation and reduction of risk. Iterative process resulting from use of the AOSE model provides a means for comparing deliberate change in workplace systems and outcomes achieved.

The session will also review selected examples of projects that have applied macroergonomic principles in successful safety and ergonomics improvements that have achieved accident frequency and severity reduction.

Macroergonomics

Background

Many factors can contribute to work related injuries and workers compensation claims and most incidents result from a combination of causes. Injures related to musculoskeletal disorder (MSD), for example, are often related to a combination of physical, psychosocial and organizational issues in the work and home environment.

The physical risk factors can usually be observed and measured with some precision and with standardized measurements for frequency of repetition, duration of activity, amount of force and posture angle. The non-physical factors are generally more difficult to measure and may not be directly observable. Psychosocial factors are usually measured by asking workers to give their opinions and perceptions in verbal or written formats. Methods that have been used successfully to address psychosocial factors include:

- One on one interviews with employees and managers to get their perceptions and opinions.
- Focus groups or other small group activities to collect information from groups of employees or management.
- Written or computer based survey instruments or questionnaires used to get worker perceptions, opinions, and comments on factors related to safety and ergonomics. Survey methods have included:
    - Standardized survey instruments developed with an established set of questions to assess a set of common identified psychosocial factors.
    - Customized instruments with items developed specifically to assess the areas of interest to the organization.
    - Sets of questions or items added onto existing company surveys or questionnaires used for other purposes.

Effectively addressing the psychosocial factors requires careful planning for each step of the process including communication, development, delivery, analysis, and follow-up. Clearly defined and tested survey instruments can help to reduce the ambiguity and facilitate interpretation of the results. Some basic considerations for success include:

- Ensure that the organization is ready to address issues before beginning process.
- Obtain expertise in survey design for best results.
- Establish a plan for survey development, administration, and response.
- Start with simple steps of interviews to do the initial level of fact-finding.
- Pilot surveys with a small group to test and validate the content and the instrument.
- Communicate expectations, purpose, results and actions to all levels of management and workforce.

- Involve workers in survey development and the remediation plans.
- Survey a representative sample of the work force and avoid conclusions based on small subsets.
- Include demographic survey questions to measure variation or important differences.
- Ensure anonymity in administering the survey and processing the results.
- Administer the survey over a short, defined time period.
- Provide a summary of results and action plans to all participants in the survey.

Applying Macroergonomic Principles to Safety Initiatives

Expand your approaches to implementing safety controls to include more formal strategies for addressing the important psychosocial and organizational issues. Begin to systematically identify, analyze and address these issues at the same time that you are implementing physical work factor controls. Some basic approaches for increasing effectiveness with psychosocial and organizational issues include the following:

Increase Participation

Maximize involvement of workers and management in the process of identifying, evaluating, and developing controls for workplace issues. Participation can increase commitment to goals, change, and process. Participation can have many levels and the method and amount should fit the organization. Model existing initiatives in an organization that have active participation and leverage these approaches for safety efforts.

Develop Cross-functional Teams

Consider cross-functional team approaches that utilize the advantages of participatory ergonomics. Basic formation of the team should include cross-functional membership of employees, operations management and supporting functions such as maintenance and engineering. Selection of team members is usually done through a combination of management nominating or selecting some members and soliciting volunteers for other members. Periodic rotation of membership can help to sustain enthusiasm and action over time. Provide team members clear expectations for their involvement. Clearly define the role for the team within the organization. Decide if the team scope will be limited to evaluating risk and advising management or will have the team have more broad responsibility for decisions on implementing changes.

Increase Communication

Increase communication in the organization using formal and informal communications systems. Encourage and reinforce new ideas recognition. Avoid focusing on negative behaviors and start looking to encourage and increase positive recognition.

Measure Perceptions

Psychosocial issues generally involve perceptions of workers and management to conditions and practices. Measure perceptions to help you get more data to make better decisions. Use surveys and questionnaires to get the data and track progress. Some formal surveys for psychosocial factors have been developed although few have been formally tested. Look for opportunities to use existing surveys or questionnaires to obtain data on important psychosocial issues relevant to ergonomic considerations.

Plan Organizational Responses to Problems
Examine your management systems for responding to complaints, claims and suggestions to ensure that the systems promote open communications, are perceived as supportive, and have a defined path for resolution. Train management on issues and need for responsiveness. Expand the involvement and interaction with medical practitioners to ensure open communication, compatible strategies for dealing with pain and injuries, and appropriate level of support.

Framework for Applying Macroergonomic Principles

The Architecture of Safety Excellence™ (AOSE) is a model for an organization to improve safety and ergonomics performance and can be used to apply macroergonomic principles and to guide team functions. The AOSE model can establish the structure for the Team and provide the framework for action within the organization. Management Direction, Commitment and Leadership coupled with Employee Involvement and Leadership are the core drivers of success in the AOSE model. The cross-functional membership of the team should include both management and worker involvement and leadership. The cornerstones of the model are Risk Assessment, System Analysis, Integrated Solutions and Progress Measurement. These elements provide the team a plan for systematic identification, evaluation and control of the risks.

Risk Assessment - Determining the degree of risk by qualifying and quantifying risk for a given operation, task, behavior, or process. Risk assessment involves the evaluation of frequency, likelihood and severity of exposure to risk.

- Frequency - The degree to which a situation occurs that provides an opportunity for exposure to an undesired event (risk).
- Likelihood - The degree to which the undesired event is expected to occur within the life cycle of the system.
- Severity - The degree of harm generated by the occurrence of the undesired event

System Analysis - Examining the workplace environment, worker capabilities, and worker motivation to perform, and the degree to which they are integrated.

- Environment - The workplace physical factors.
- Capability - What people know how to do and their understanding of why doing it is important.
- Motivation - What influences people to behave as they do or should.

Integrated Solutions - Designing and implementing strategies for improving systems. System examinations provide opportunities to correct discrepancies that drive loss.

- Engineering - Control of workplace condition and prescribed methods.
- Training & Education - Development, Education & Training solutions.
- Behavioral - Consequence management to increase safe and effective behavior.

Progress Measurement - Measuring the extent of change achieved and the effect of the change on critical results. The aim is to optimize how progress is measured and tracked toward achieving stated objectives so that continuous improvement is fostered. This cornerstone integrates metrics of progress and process to measure incremental performance improvement and its effect on the outcomes of risk.

Effective Process for Team Risk Assessment

The team will need to have a format or method defined for the risk assessment and analysis. One method that has been used successfully is Residual Risk Reduction™ (R3). This is a group process for completing a risk assessment and system analysis with the goal of reducing risk. R3 provides the team with structured process to understanding, prioritizing, assessing, and reducing risk. The focus is on the activities that are done that have risk. The basic process for the team includes:

- Identify and prioritize the risk of activities that are done by the workers
- Analyze the activities and define concerns
- Score risk of each concern using the Risk Rating Scale
- Identify existing controls and evaluate effectiveness of these controls
- Identify new controls using AOSE model to guide systems analysis of environment, capability and motivation.
- Implement new controls using AOSE model to integrate engineering, training, and behavioral solutions.
- Re-score the task with reduced risk after new controls and calculate impact on risk.

The team is provided with a rating system to guide the risk assessment process. The ratings assess three factors and use a one to five scale with defined anchor points for the scale. See Table 1 for sample rating scale that can be used. The first factor is frequency, which is the measure of how often the task is completed. The second factor is the likelihood of injurious contact with the hazard when the task is completed. The third factor is the rating of worst plausible severity of the injury or illness caused by contact with the hazard.

Rating	Frequency	Likelihood	Severity
1	< once per shift	Impossible	First Aid
2	≥ once per shift	Unlikely	Medical Treatment
3	≥ once per hour	Possible	Lost time, full recovery
4	≥ once per five minutes	Probable	Some permanent impairment
5	≥ once per minute	Multiple	Major permanent impairment or death

Table 1. Sample Residual Risk Reduction ™ Risk Rating Scale

Once the individual ratings are determined, calculate the risk index by multiplying the individual ratings for each hazard listed. F x L x S = Risk Score If the task has multiple sources of risk, then these can be combined into a total risk index. Calculate the risk index for the job task by adding together the product of the ratings for the individual hazards. These ratings of risk can be used to set priorities and to measure progress as risk is reduced.

After the risk assessment, then the Team conducts the analysis of the task and work systems. For ergonomics, this will include the physical environment as well as the organizational and psychosocial risk factors that can affect motivation and performance of the tasks. The systems analysis should lead to the development of the plan for integrated solutions including the engineering changes, the training and education, and the behavioral components.

The team should ensure that there is a process to measure the activities, process and results. These measures help to demonstrate success and effectiveness and can be used to generate additional support and enthusiasm among team members and within the organization. When success is achieved, it is also important to recognize and celebrate the contributions of the team.

Using Macroergonomics to Improve Safety

Organizations have used the team model successfully to drive change in safety and implement macroergonomics principles. A manufacturer of paper food containers was interested in increasing associate participation in the plant safety process. The plant had been operating for more than 20 years, printing and die cutting retail packaging for baked goods produced by its customers. Approximately 300 associates were employed in the operation across three shifts. Low back pain complaints and cumulative trauma incidents dominated the loss history that was slightly higher on an incident rate basis than the rest of the corporation, but lower than industry average.

A cross-functional team of 13 production associates and supervisors was formed to identify opportunities. After chartering by the plant manager, and review of loss trends by work activity, the team selected a system with no incident history, unanimously, as the first to be analyzed.

Because of the variety of packaging products produced, the plant was designed to accommodate an extensive storage volume in an attached facility known within the plant as the “High-Bay”. This Automated Storage & Retrieval System, housed in a 100’ foot tall structure, consisted of an automated forklift that traveled on rails between two open storage racks. Bar-coded pallets of product were scanned by the ASRS unit and transported/lifted to a storage slot designated for the particular product. More than 20 years of use had introduced enough variance into the mechanical equipment that what was once a rare occurrence, a pallet of product becoming “jammed” so that the ASRS unit could not retrieve it, became an almost daily event. Procedure called for a maintenance technician to climb into the rack and straighten the pallet using a six-foot pry-bar. The activity was known within the plant as “Un-Jamming the High-Bay”.

Concerns included:

- Head Injury - Fall from Elevation
- Various Injury - Struck by - Using Pry Bar
- Head Injury – Struck by - Falling pry bar
- Torso injury - Caught between load & Rack
- Muscle strain - Using Pry Bar
- Extremities Fracture - Fall between racks

- Electric shock-contact with ASRS circuits
- Extremities Injury - Fall from ASRS unit while traveling
- Torso injury - caught in machine pinch point -automatic motion
- Pedestrians in aisle struck by falling skids
- Head Injury – Falling object - Hoist chain failure

Examination of the system revealed that:

- Wear and use had introduced inaccuracy in reading of the bar-coded pallets, travel of the ASRS unit, and placement of the pallet in the assigned storage slot,
- Loads on pallets were often out of square from the production lines,
- Procedures for clearing jams were minimal and poorly understood,
- Personal protective equipment was inadequate

Interventions identified included:

- Updating ASRS proximity sensors to increase sensitivity and more precisely position the product pallets,
- Revamping palletizing operation to more precisely center and square the product on the pallet,
- Revising preventive maintenance procedures so that the system is tested daily and maintenance of sensitive parts is on a predictive schedule,
- Realigning racks so that pallet slots are square and level,
- Redesigning operator stations on ASRS units to provide protection from overhead hazards,
- Updating PPE and procedures for jam clearing,
- Providing specific training to maintenance technicians,
- Conducting post training, as well as ongoing, observation & feedback to maintenance technicians

While it may not be necessary to point out, the integrated nature of risk reduction strategies like this has compounding effects on the system inputs. Obtaining fall arrest equipment designed specifically for the application, designating individuals to be trained and certified in its use, and frequent work observation & feedback can be expected to work in concert to motivate use of the new procedure.

In this case, the associates were asked to participate had no specific training or experience with system safety or organized risk assessment prior to joining the group. The strategy summarized was the result of their second half-day meeting. Repairs and preventive maintenance to the racks and ASRS unit as well as "squaring" product on pallets could be expected to reduce the occurrence of jams. Thus, the frequency of the activity is reduced and occurrence opportunity for all of the concerns associated with it decreases. Interventions like securing tools with lanyards and use of observers to influence performance of specific behaviors reduce the likelihood of occurrence of specific concerns when it is necessary to perform the activity. And, severity is reduced in the event of occurrence when personal protective equipment such as state of the art fall arrest devices is used.

There was some trepidation expressed by the team when they presented the results of their analysis to the plant leadership group. Submitting and defending proposals for expenditures on improvement projects was as new to some as risk assessment and system analysis. There were, after all, no incidents or associated loss costs from "Un-jamming the High-Bay". As it turned out, the leadership group had parallel initiatives to explore principles of Lean Manufacturing™ and Six Sigma™. They immediately recognized that the team had identified an activity with significant opportunity for improvement. In addition to the significant risk reduction to be achieved through implementation of the proposed new controls, increased efficiency would also be gained as the occurrence of “jams” is decreased. Expenditure for the proposed risk reduction strategy was enthusiastically approved along with sincere thanks and strong encouragement to the team to continue their work through weekly meetings.

Case Study #2

A textile finishing plant that processed sewing thread had formed a team to identify and pursue opportunities to improve performance. The integrating initiative was safety.

A perennial source of injury was low back pain experienced by associates when pushing four-wheel carts of thread packages. A cursory root cause investigation revealed that waste thread became wrapped around the axles of the cart wheels to the point that they froze and did not roll as designed. This had influenced system outputs, or demands, within the plant that included:

- Almost monthly complaints of low back pain from associates within the 900 person plan population,
- A highly skilled maintenance technician dedicated, full time, to the removal of thread chokes on cart wheels or replacement of wheels that became too badly damaged,
- An inventory of cart wheels needed for the replacements.
- A contract with an outside vendor to treat the concrete floor, on a monthly basis, to facilitate daily removal of accumulated thread on the floor using manual and powered “brooms”,
- Aprons worn by associates at least partially to contain thread “ends”. (For each of the 1,500,000 thread packages produced each week, two 18” waste ends are produced.)

Ideally, Operators were expected to place waste thread ends in their aprons. Examination revealed that this was being performed successfully approximately 60% of the time. A variety of factors contributed to this baseline performance including:

- Speed of the processing equipment,
- Relative humidity which contributed to “static cling” of the thread to the operators hand,
- The type of thread fiber processed,
- Experience and skill of operators.

Essentially, 600,000 waste ends were falling to the floor each week. This variance was resulting in the set of system outputs described above.

In the course of completing a performance improvement project, the team addressed each of the contributing factors:

- Observation and feedback was provided for the behavior: “When thread is cut, the waste end is placed in the apron.”
- Through the feedback process, a suggestion was made to provide a small square of synthetic abrasive pad (Scotch-Brite™) for the aprons worn by operators. The waste end was easily

"grabbed" and held by the pad increasing the ease in which the operator removed it from their hand.

After this intervention, observed performance of the critical behavior increased to a sustained level of approximately 98% effective. This resulted in:

- Almost complete elimination of low back pain complaints from pushing four-wheeled carts and an 80% reduction in incurred incident costs overall,
- The maintenance technician dedicated, full time, to the maintenance of cart wheels went back to job he was trained to do; maintaining production machines,
- The inventory of cart wheels needed for the replacements was almost nil which freed up productive space in the facility and reduced equipment costs,
- The vendor contract to treat the concrete floor, on a monthly basis, was adjusted to a semi-annual basis,
- Time spent on daily floor cleaning was reduced by almost 50%

After three years, the performance leadership team is still active, identifying and pursuing improvement projects.

Summary

Accidents result from multiple causes and factors. It is necessary to recognize the importance of the psychosocial and organizational factors if an organization wants to achieve safety excellence. Macroergonomics provides methods and tools to expand our ability to identify, analyze and address a broader range of these factors. One effective way to apply macroergonomic principles is to use a systems approach that incorporates cross-functional teams to drive change in an organization. The use of teams can increase participation of the workforce in problem identification and solution development and help an organization move beyond basic programs to achieve safety excellence.

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