Get Started on Implementing Effective Operational Discipline Programs to Help Improve Process Safety and Safety Performance[1]

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Operational discipline (OD) describes human behavior in following required systems, every time, to consistently achieve organizational goals and overall operational excellence [1, 2]. While a focus on OD is not a panacea, OD is a fundamental part of effective programs for achieving excellent performance in process safety, safety, quality, reliability, and productivity [2, 3, 4]. Well-designed management systems do not achieve these goals in isolation; the disciplined efforts of involved personnel in effectively implementing and following system requirements continuously are needed. The failure to follow a system requirement, even just once, due to human error, inattention, complacency, or some other reason, can result in significant consequences, such as personal injury, environmental harm, and business loss.

For example, an incident investigation by the U.S. Chemical Safety Board (CSB) [5] concluded that an operator opened the bottom valve of an operating polymerization reactor, apparently bypassing an active pressure interlock, instead of the intended action of opening the bottom valve of a nearby reactor that was being cleaned. The resulting large release of hot, flammable material from the operating reactor ignited, leading to five fatalities and major damage to the facility. While human errors such as this example should be anticipated and appropriate safeguards should be provided to help prevent serious injuries and other significant consequences, a focus on OD – doing the right thing, every time – is an essential component of effective safety programs and the ability to achieve excellent safety performance. Steps for getting started in implementing an OD program, or improving an existing effort, are discussed below.

Precursors to OD

Precursors to getting started on implementing OD programs include:

- Recognition and assessment of hazards
- Implementation of risk management programs.

It's necessary, of course, to know what hazards may be present, so initial and continuing efforts to identify and assess hazards in the workplace define the type and level of risk management program needed [2, 6]. If the hazards are not identified and assessed properly, then how can appropriate safeguards and systems be implemented and maintained to manage the risks associated with those hazards? If process hazards, such as toxicity or flammability, are present, for example, then a process safety program is needed. Depending on the actual level of risk, quantity of hazardous materials present, intrinsic hazards, processing conditions, reactions, and other factors, the requirements of a process safety program may

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vary and may or may not require regulatory compliance, such as with OSHA's Process Safety Management standard or other regulations in the United States. Occupational safety, industrial hygiene, environmental protection, and other programs may also be needed to help ensure all hazards are appropriately managed.

As shown in Figure 1, effective safety programs consist of three interrelated foundations [2] comprised of:

- **Safety culture and leadership** – Safety culture and leadership help define how an organization approaches and prioritizes problems and issues related to managing safety [2, 7]. Is safety a core value with high priority in all cases, or is it more of an afterthought subject to potentially conflicting organizational priorities such as cost or productivity? Safety culture influences the daily behaviors of leadership and workers, who either reinforce and improve the culture over time or allow it to degrade. Safety culture and leadership are part of the overall organizational culture that encompasses all the ways work is or should be done and how it is impacted by safety considerations and requirements. In a weak safety culture, or with unaligned leadership, implementation of effective safety programs is often constrained and achievement of excellent safety performance is difficult.
- **Safety systems** – Comprehensive management systems provide a framework to ensure hazards and associated risk are identified, evaluated, and controlled [2, 7]. In many cases, regulatory requirements provide a good starting point for defining the needed systems and requirements, but in all cases, properly evaluating risks that may be present is required to ensure they are controlled and managed appropriately. This may necessitate going beyond the minimum essential practice defined by regulations or it may lead to complying with regulatory requirements when not required. Regulations (e.g., OSHA, EPA), consensus industry standards (e.g., National Fire Protection Association, American Petroleum Institute), industry guidance (e.g., Center for Chemical Process Safety, American Society for Safety Professionals), and extensive literature provide detailed guidance for implementing appropriate safety management systems.
- **Operational Discipline** – OD, as defined previously, relates to how well safety systems are followed and is discussed further below [2, 8, 9, 10]. OD is influenced by many factors, including safety culture and leadership, quality of safety systems, and other human behavior or human factors programs.

Some precursors related to safety culture, leadership, and safety systems that impact the effectiveness of an OD effort are listed in Table 1. Consideration should be given to implementing or strengthening safety programs in these areas.

Figure 1 – Foundations of an Effective Safety Programs (adapted from [2])

Table 1. Some precursors to effective OD programs

- Establishing safety as a core value (vs. potential conflicting priorities such as cost or productivity)
- Consistent and visible leadership commitment to safety
- A sense of vulnerability to support safety awareness and engagement and to avoid complacency
- Open communications
- Monitoring and review of key performance indicators
- Implemented risk management systems
- Documentation of operating procedures and safe work practices
- Effective and timely training practices
- Fitness-for-duty programs to mitigate possible worker impairment due to stress, fatigue, alcohol, prescribed or over-the-counter medications, or illegal drugs
- Management of change programs to identify and manage new hazards that may be introduced
- Equipment inspection and testing programs to help ensure tools and equipment are reliable and safe to use

OD Program Characteristics

The characteristics and importance of effective OD programs have been discussed several times [2, 11, 12, 13] and have recently been reviewed in the context of achieving excellent process safety performance [3, 4], reducing loss of containment incidents [14], and as a leading indicator of plant performance [15]. OD programs comprise both organizational and personal OD efforts. The characteristics that describe Organizational OD [2, 11] are intended to help company and/or facility leadership develop effective OD programs based on:

- **Leadership focus** – Leaders emphasize and provide a positive work environment, managing processes and resources for effective programs and employee engagement. Leaders are

personally involved and passionate for safety and model the behaviors they expect from their organization.

- **Employee engagement** – Employees understand and value the importance of safe work activities and contribute to organizational programs and activities.
- **Procedural principles** – Correct ways of doing work are defined and completed as planned, following documented and authorized systems and procedures.
- **Housekeeping and workplace standards** - Standards are established for maintaining safe equipment, tools, and facilities. Employees are proud of their work environment and consistently maintain high levels of housekeeping.

Organizational OD efforts are closely related to good safety culture and leadership practices. As shown in Figure 1, effective supplemental safety management systems help ensure workers at all levels in an organization know how to do their work correctly and safely every time.

The characteristics describing personal OD [2, 11], as shown in Figure 2, are intended to support the day-to-day focus on OD to help ensure all employees:

- Know how to do their work tasks correctly and safely (**Knowledge**)
- Commit and plan to do them the correct way without deviations or shortcuts, based on training (**Commitment**)
- Anticipate and are prepared for what could go wrong or look for and recognize what may be different in their current work environment and respond accordingly, based on training and experience (**Awareness**).

The goal is to have knowledgeable, prepared, experienced workers at all levels of the organization who account for the existing work environment rather than have an unquestioning focus on strict adherence to procedure when circumstances are different or changing. This requires developing appropriate operating procedures and effective on-the-job training for required work activities, which also include recognition and troubleshooting of possible deviations and the correct ways to respond to them.

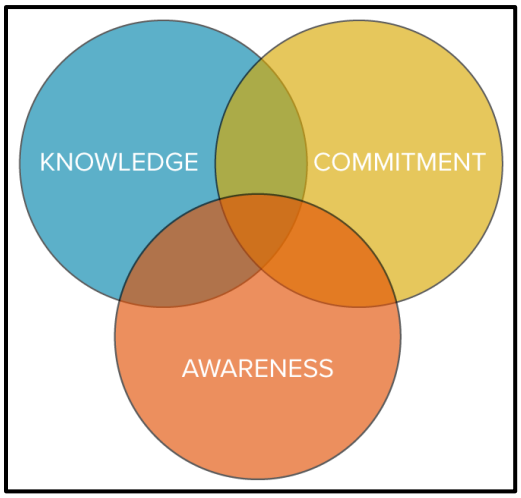

Figure 2 – Characteristics of Personal OD [2, 11]

A summary of the OD program characteristics and their relationship is shown in Figure 3.

Getting Started on Implementing Effective OD Programs

Getting started in implementing an effective OD program or improving an existing program, of course, depends on your starting point and intended goals. Key activities, which will be discussed in following sections, include:

1. Focus on OD improvement
2. Raise awareness and value for OD
3. Evaluate OD performance
4. Identify, prioritize, and pursue improvement opportunities
5. Sustain and renew OD program activities.

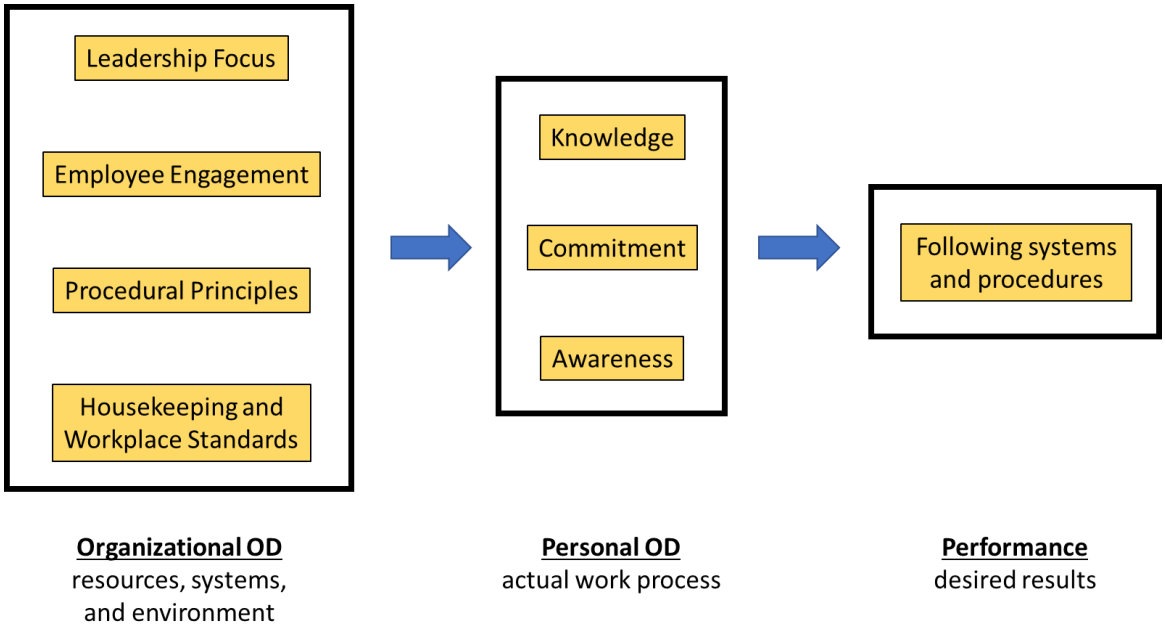

Figure 3 – Relationship of OD Program Characteristics [2]

1. Focus on OD Improvement

Management should consider improving OD for the following reasons:

- Required part of effective safety programs, as shown in Figure 1
- Poor performance creates desire to improve
- Good performance creates desire to avoid complacency and sustain.

Some of the benefits of an effective OD program include [2, 8]:

- Process (and other) hazards and risks are identified, evaluated, and managed
- Equipment and facilities are properly designed, operated, and maintained
- Management systems are well designed, implemented, executed, and supported
- Operating problems and incidents are consistently investigated and corrected.

As a result, process safety and EHS performance, productivity and cost, and product quality performance should improve. To achieve or improve these results, appropriate management focus on improving OD is required to get started due to the need to [2]:

- Demonstrate personal attention and commitment to the effort
- Provide appropriate resources to support program execution
- Develop effective processes to facilitate employee awareness, understanding, and involvement
- Implement, improve, standardize, and maintain needed systems and activities
- Support, evaluate, and monitor performance.

Failure to implement or sustain effective OD programs can be catastrophic. For example, a 2005 refinery explosion investigated by the CSB [16] resulted in 15 fatalities, 180 injuries, and major facility damage, as shown in Figure 4. While the CSB identified many causes, Table 2 highlights some of the OD issues identified in the CSB investigation of the incident. Subsequent investigation [17] of several company refineries found "instances of a lack of OD, toleration of serious deviations from safe operating practices, and apparent complacency toward serious process safety risks at each refinery."

Table 2. Some examples of OD issues identified by CSB refinery investigation (adapted from [16])

- Management did not emphasize the importance of following procedures as evidenced by its lack of enforcement of the MOC policy, its acceptance of procedural deviations during past startups, and its failure to ensure that the procedures remained up-to-date and accurate, contributing to a work environment that encouraged operations personnel to deviate from procedures
- Inadequate training for operations personnel contributed to causing the incident. The hazards of unit startup and for abnormal situations were not adequately covered in operator training.
- A "check the box" mentality was prevalent, where personnel completed paperwork and checked off on safety policy and procedural requirements even when those requirements had not been met, contributing to a culture of "casual compliance"
- Managers did not effectively implement their pre-startup safety review policy to ensure that nonessential personnel were removed from areas in and around process units during startups and that the adequacy of all safety systems and equipment, including procedures and training, process safety information, alarms and equipment functionality, and instrument testing and calibration were verified
- A lack of supervisory oversight and technically trained personnel during the startup, an especially hazardous period, was an omission contrary to refinery guidelines. No experienced supervisor or technical expert was assigned to the startup after the Day Supervisor left, although safety procedures required such oversight.

- An effective incident investigation management system to capture appropriate lessons learned and implement needed changes had not been implemented.
- The mechanical integrity program did not ensure that deficiencies were identified and repaired prior to failure, resulting in the "run to failure" of process equipment.

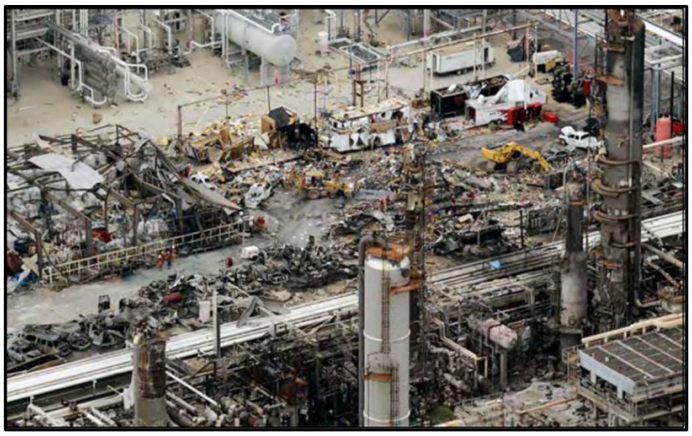

Figure 4 – Refinery Explosion and Fire [16]

An effective OD program emphasizes completing all tasks correctly and safely every time, regardless of the role of individuals in the organization – it is important to recognize that OD is for everyone, not just for operators. Trevor Kletz, for example, observed that:

> Every accident is due to human error: someone, usually a manager, has to decide what to do; someone, usually a designer, has to decide how to do it; someone, usually an operator, has to do it. All of them can make errors but the operator is at the end of the chain and often gets all the blame. We should consider the people who have opportunities to prevent accidents by changing objectives and methods as well as those who actually carry out operations [18].

It is also important to recognize that OD improvement efforts must relate to specific, local site or organizational issues, based on differing safety culture, leadership, work activities, hazards, and/or geographic locations, that likely vary from one site or area to another, especially in larger companies or facilities. Common issues may be identified, but local differences may lead to different priorities for improvement.

It is necessary, of course, to start where you are at, recognize where you are going, and determine where you actually want to go in terms of improving OD. The FLAME model [2] describes best practices for leadership efforts in getting started on improving OD:

- **Focus** – Develop a vision to enable appropriate focus on OD and effectively communicate the vision and associated goals to develop awareness and engage site personnel, which are supported daily through leadership attention and priorities

- **Leadership** – Leadership acts as visible role models committed to continuous improvement and excellent OD performance through use of effective, consistent leadership practices
- **Accountability** – Organization, team, and individual goals include a focus on OD with clear expectations on performance, feedback, and recognition as appropriate
- **Measurement** – Metrics, audits, and other tools are defined to periodically assess site activities, performance, and progress toward goals
- **Engagement** – Leaders provide a work environment which supports the engagement and support of site personnel, based on good communication processes, employee input and involvement, and interdependent behaviors. Site personnel know they are important to success and that their contributions are valued.

Although OD improvement is ultimately the responsibility of all organizational leaders, it can be helpful to assign an OD leader to provide additional focus and accountability for implementing and sustaining effective OD programs. An important goal is to create an OD flywheel [19, 20] or habit [21], where initially small changes lead to larger improvements and momentum over time to achieve OD goals and improve performance.

2. Raise OD Awareness and Engagement

While developing an OD improvement vision and specific improvement goals, it is important to share these with affected employees to raise awareness and engagement of what OD is, and why it is important, as well as to solicit broad employee input and participation on possible causes and improvement opportunities. This can be done through the introduction and discussion of OD program characteristics and goals at safety and other meetings, through daily face-to-face interactions, and through other communication pathways. OD improvement workshops, as discussed in a later section, can be used to provide focused attention to OD issues and improvement plans away from normal job activities, helping to engage employees through their active involvement in identifying problem areas and determining priorities for future improvement activities. An important factor to emphasize, based on experience, is that operational discipline programs promote positive discipline, such as training for an important goal or maintaining an important practice, rather than promote disciplinary actions, such as those that might be related to human resource activities. With a good safety program in place and a primary goal to execute and sustain system requirements, a good message to communication can be “discipline (OD) equals safety.”

Everyone should understand that, even well-trained employees will make mistakes. Assuming a person makes safety-critical decisions every day, and assuming an error rate of 1 mistake in 100 opportunities (0.99 daily success rate), the chances of an employee completing all work task correctly every day for a year (based on 250 work days) would be about 8% ($[0.99]^{250}=0.08$). Human error must therefore be anticipated and appropriate safeguards should be provided to help prevent serious injuries and other significant consequences. A focus on OD is an essential component of effective safety programs, but not the only component as discussed earlier.

Opportunities to increase the probability of success in reducing human error through improved OD and other actions, particularly for higher risk activities, are critical for improving performance in many areas. The previous refinery incident provides a good example of the value for good OD, but incidents related to the company, specific site, and related facilities should be used help personalize and engage workers with emphasis on how their work environment and safety can be affected. Basic to an understanding of the value of OD is the recognition that good OD (as a percentage) lowers the risk of safety, quality, and other operational problems, as shown in Figure 5.

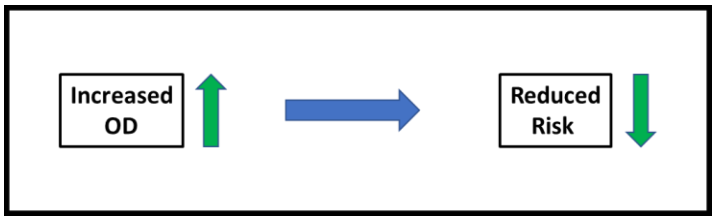

Figure 5 – Increased OD Lowers Risk of Undesirable Events [2, 11]

This can be illustrated for employees in two ways to help build awareness and engagement. First, The safety triangle, as shown in Figure 6, illustrates qualitatively how significant consequences, such as serious injuries or catastrophic incidents, are often predicted by a larger number of smaller, undesirable, unsafe acts, or behaviors. A focus on minimizing or eliminating problems at the bottom of the triangle helps to prevent the more serious events at the top. Thus, an effective OD program works to reduce the number of unsafe acts and undesirable behaviors in the organization, as seen at the base of the safety triangle, helping to prevent more serious incidents and injuries. This is especially important for many higher-risk activities, such as working with highly toxic materials or electrical work. In these cases, the base of the safety triangle can be very narrow, as shown in Figure 6, meaning that even one unsafe act or mistake can directly lead to a serious injury or incident.

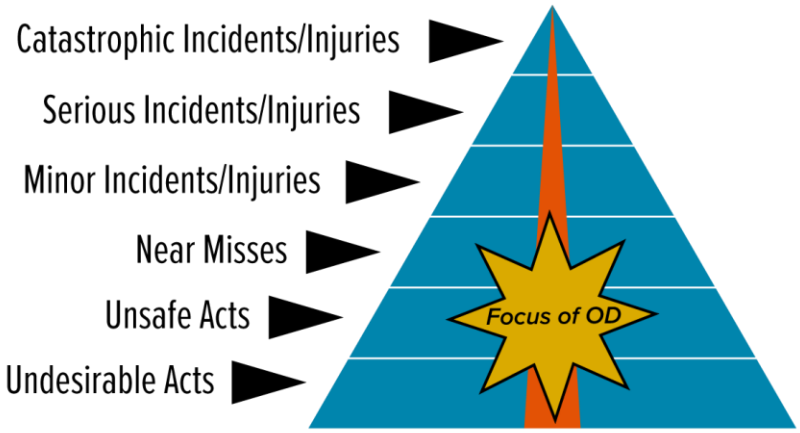

Figure 6 – The Safety Triangle Illustrates the Value of OD Improvement Programs [2, 11]

Second, the impact of OD on risk can also be illustrated in a qualitative risk matrix, as shown in Figure 7, which is often used in process hazard analysis (PHA) to estimate the risk of different hazardous scenarios. Poor OD typically increases the potential frequency of a hazardous event when using a risk matrix, since the worst-case consequences are generally used. This can increase the risk from level R_1, the "perceived" risk where OD is not considered, to a higher level, the "actual" risk R_2, depending on the extent of the frequency increase. The resulting higher risk may be considered unacceptable in a PHA, but might not be fully evaluated if OD factors (which may impact the initiating frequency of the event and/or the reliability of safeguards) are not accounted for.

Many layers of protection are typically provided to help prevent injury or significant incidents associated with process hazards, yet, when an injury or incident occurs, all or many of the safeguards have failed for one reason or another. OD problems, such as a failure to follow procedures, are often one of the major reasons. In this respect, OD, or lack thereof, becomes a "common cause failure" that might impact actions taken by operators, tasks done (or deferred) by maintenance personnel, the quality of new construction work, the reliability and error tolerance in design work, and so forth.

Human error and related OD issues that can impact risk evaluation in a PHA or other activity must therefore be anticipated and protected against, including the use of additional risk evaluation methods that better account for failure frequencies, if needed.

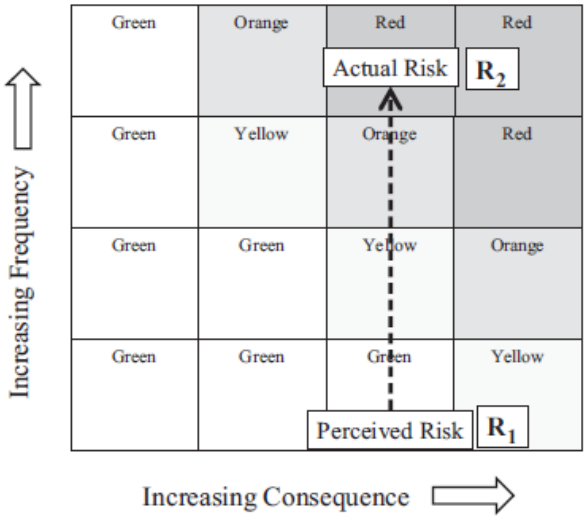

Figure 7 – Poor OD Can Lead to Higher Risk of Hazardous Events [2]

3. Evaluate OD Performance

Measurement is an essential activity for evaluating current performance and the possible impact and priorities of potential improvement opportunities. Sources of information of information for evaluating OD [2, 11, 13] include:

- ***Incident and injury data*** – Investigations of incident, injury, and near-miss events focus on the identification of causal factors to learn from the event and prevent re-occurrence. Many root causes relate to OD and human performance, such as failure to follow a procedure, improper design, and improper maintenance. These failures should be further investigated to identify system and cultural causes and to provide evidence of and prioritization for addressing OD issues at a site. Identifying the number and trends of incidents related to OD factors, for example, highlights the presence of and possible impacts of poor OD as well as the identification of potential improvement opportunities.
- ***Audits*** – Audits are conducted periodically to identify gaps in management system implementation and performance and often provide examples of poor OD. Audit findings should be reviewed to determine if they relate to OD issues and additional related findings can then be developed. In addition, specific OD audit protocols [22] can be incorporated into audits to provide additional focus on potential issues.
- ***Metrics*** – Many safety, quality, and operational metrics already being collected, as shown in Table 4, can provide insights on OD. Many action items may be overdue, for example, indicating OD problems related to the timely resolution of identified improvements. In other cases, product quality problems, low process utilization, and high waste levels may indicate OD causes that should be investigated further. New metrics can also be developed as needed to provide additional insights on OD performance. Trends of data over time can provide insights on whether issues are increasing or decreasing and whether performance is improving. An example of metrics trends is shown in Figure 8.
- ***Surveys*** – OD assessments can be developed using the OD characteristics and related factors discussed earlier, using internet survey tools or group discussions, depending on the sample size and the degree of analysis desired. Additional free-form entry of comments should be allowed when using internet tools, and the results should be confidential to encourage honest participation. An example of a personal OD survey is shown in Figure 9, where the x-axis could be different sites, different groups of employees (e.g., management, operators, contractors), and different types of employees (e.g., work group, experience level), which can be used to examine the survey data from different perspectives. The responses in this example indicate some possible significant overall and local OD issues related to following procedures (e.g., approximately 20% of overall responses indicate a willingness to deviate from procedure, and at one site, this value is over 50%). While surveys should generally be treated as "soft" data, representing employee perceptions, rather than "hard" data, such as metrics related to loss of primary containment or other discrete events, survey results can be useful in helping to evaluate human perspectives and beliefs that impact OD.

OD evaluation must be a continuing process to help measure progress, sustain improvements, and identify potential new issues, requiring that appropriate measurement frequencies be developed.

Table 3. Some examples of metrics that may provide insights on OD performance [2, 11, 12, 13]

- Incidents, injuries, and near misses with OD causal factors
- Audit findings that relate to OD issues

- Overdue action items (e.g., incident or PHA recommendations)
- Overdue scheduled activities (e.g., maintenance tests, procedure revisions)
- Loss of primary containment events (e.g., spills)
- Environmental permit violations
- Activation of safeguards (e.g., alarms or interlocks)
- Product quality evaluations
- Waste levels
- Equipment utilization rates

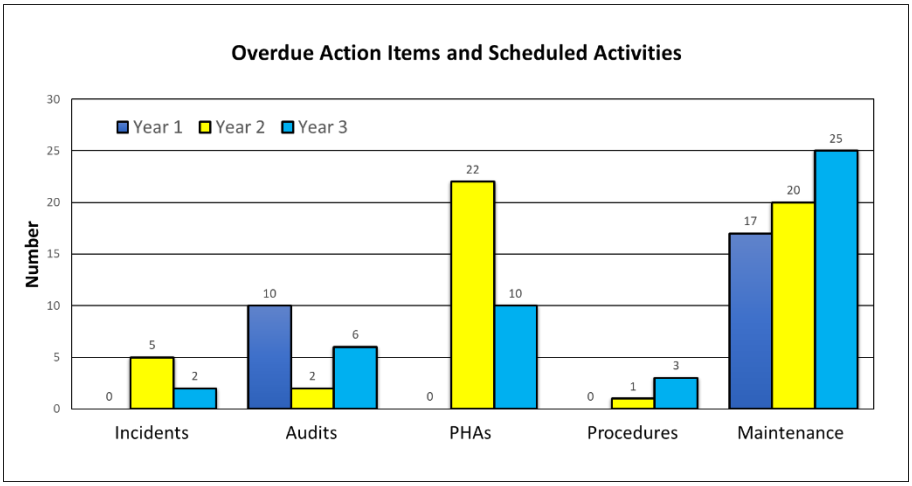

Figure 8 – OD Metrics and Trends Can Be Used to Identify Potential Issues

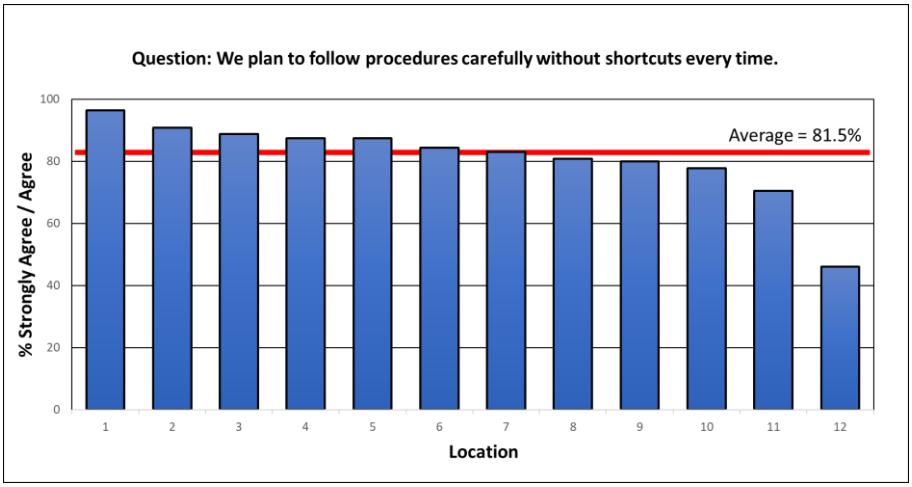

Figure 9 – OD Surveys and Trends Can Be Used to Identify Potential Issues

4. Identify, Prioritize, and Pursue Improvement Opportunities

Opportunities for improving OD can be identified from employees input and analysis of performance data, as discussed previously. A workshop approach has been used [11, 23] to engage broad cross-sections of facility employees in identifying and prioritizing OD improvement opportunities. This helps raise employee awareness and understanding of OD issues, builds value for OD, engages employees in identifying problems and developing solutions, and helps get the organization started on prioritizing and pursuing improvements through development of selected activities and plans. Some activities may be easy to implement and some may be much harder, requiring significant resources and time, but ultimately providing greater benefits. Generally, both types of activities should be considered, given overall resource constraints and competing activities. Prioritization can be based on factors such as overall benefit, required resources, time to complete, and level of management support.

Workshops can be of varying length depending on site size and needs, typically 4 to 8 hours, but can be a good way to engage and energize OD improvement efforts. Multiple workshops may be needed to include appropriate site personnel, and in some cases, it can be interesting to view the results from workshop groups that represent participants from across the site against workshop groups that may be from different areas of a facility or different employee groups (e.g., management groups and operator groups). An example agenda is provided in Table 4, requiring advance work to prepare relevant hard (e.g., metrics) and soft data (e.g., survey results) for review by participants.

Table 4. Sample OD workshop agenda [11, 23]

- Purpose and introductions
- What is OD and why is it important?
- Breakout groups – build value for OD programs (e.g., detailed site incident review)
- Hard data review – incident, injury, audit, and metrics data and trends
- Breakout groups – discuss data and identify improvement opportunities
- Soft data review – survey results
- Breakout groups – discuss data and identify improvement opportunities
- Discussion – prepare summary list of improvement opportunities and prioritize list
- Breakout groups – each group takes a different opportunity to develop path forward
- Review group results and plan overall path forward

OD improvement opportunities obviously will be specific to different locations or groups, based on the data developed and reviewed. The precursor list provided in Table 1 should be considered for possible activities, and some opportunities may overlap with safety culture and management system efforts. A list of possible improvement activities is shown in Table 5. Development of a documented “tool box” or database of OD-related projects or improvement approaches, including lower priority projects that have previously been identified, can provide a useful resource for other facilities and future work.

Table 5. Examples of possible OD improvement activities (adapted from [2])

Consider if:

- All personnel are aware of and value OD
- Procedures are current, accurate, and followed consistently without shortcuts

- Effective training is conducted for job-specific activities and troubleshooting and that training is conducted on the right frequencies
- Checklists [24] or reminder cards can be used to supplement procedures, especially for infrequent and higher-risk activities
- Sufficient time is provided to support planning and conducting safe work activities
- Factors used to evaluate the strength of a workplace [25] or safety culture [2, 7, 26] may influence OD more broadly
- Some variation of "pointing and calling" [21] can help reduce mistakes, such as a required communication after completing a task
- Complacency due to good performance is a factor and if a sense of vulnerability needs to be reinforced
- Sufficient and capable resources are provided to support safety-related activities
- The organization has open and frequent communication
- The organization promotes pride in the organization through shared values
- Behavior-based safety programs can improve commitment to safety
- Levels of employee participation are good or show a lack of participation
- Recognition practices are effective
- How many distractions may be present in the workplace or impacting employees
- People are willing to ask for help or believe in stop work guidance
- All levels of leadership are visibly and consistently supporting safety and OD improvement efforts
- Incident investigations, audits, and performance metrics evaluate OD causal factors, including quality and other aspects of expected operations
- Company, site, and/or area OD leaders would be useful
- A company-wide or site-wide network to share and support OD-related activities would be useful.

5. Sustain and Renew OD Program Activities

The pursuit of high levels of OD performance is a continuing journey that is fundamental to effective safety programs, as shown in Figure 1, requiring management focus and the participation of everyone at a facility. Everyone should understand why changes are being made, what the benefits are, how long is required, what kinds of results are expected, and what involvement and follow-through are needed [2]. Sustaining progress requires leaders to embrace OD and understand OD is not a project, it is a series of projects and an ongoing process. Leadership can ensure the program is sustained in the following ways:

- For each identified OD improvement project, metrics and milestones should be developed to gauge progress and help ensure that gains are sustained
- Once one project is complete, new ones should be identified for further work and improvement
- Existing and new requirements should be standardized based on project results and broad employee review
- Expectations for consistent application should be clearly communicated and understood

- Progress should be periodically reviewed by management and the results shared with employees for awareness, feedback, and follow-up as needed
- Adjustments to projects can be made based on new information or new priorities
- Recognition of progress should be provided when appropriate.

Significant change is rarely easy, but implementation of a new or improved OD program can result in broad safety and operational performance gains, especially when effective management systems have already been implemented and a strong culture and supportive leadership are already in place. A review of current performance and goals can help determine if the time to get started is now.

References

[1] J. A. Klein, "Operational Discipline in the Workplace," *Process Safety Progress,* vol. 24, pp. 228-235, 2005.

[2] J. A. Klein and B. K. Vaughen, Process Safety: Key Concepts and Practical Applications, CRC Press, 2017.

[3] J. A. Klein, "Tune Up Process Safety Performance," *Chemical Processing,* no. Oct., pp. 14-20, 2019.

[4] J. A. Klein, "Sustaining Effective Process Safety Programs in CPI Facilities," *Chemical Engineering,* no. Feb., pp. 24-29, 2020.

[5] U. S. Chemical Safety Board, "Vinyl Chloride Monomer Explosion," Report No. 2004-10-I-IL, 2007.

[6] Center for Chemical Process Safety, A Practical Approach to Hazard Identification for Operations and Maintenance Workers, Wiley-AIChE, 2010.

[7] Center for Chemical Process Safety, Guidelines for Risk Based Process Safety, Wiley-AIChE, 2007.

[8] Center for Chemical Process Safety, Conduct of Operations and Operational Discipline, Wiley-AIChE, 2011.

[9] J. A. Klein, W. M. Bradshaw, L. N. Vanden Heuval, D. K. Lorenzo and G. Keeports, "Implementing an Effective Conduct of Operations and Operational Discipline Program," *Journal of Loss Prevention in the Process Industries,* vol. 24, pp. 98-104, 2011.

[10] B. K. Vaughen, J. A. Klein and J. C. Champion, "Our Process Safety Journey Continues: Operational Discipline Today," *Process Safety Progress,* vol. 37, pp. 478-492, 2018.

[11] J. A. Klein and B. K. Vaughen, "A Revised Model for Operational Discipline," *Process Safety Progress,* vol. 27, pp. 58-65, 2008.

[12] J. A. Klein and E. M. Francisco, "Focus on Personal Operational Discipline to Get Work Done Right," *Process Safety Progress,* vol. 31, pp. 100-104, 2012.

[13] J. A. Klein and B. K. Vaughen, "Implement an Operational Discipline Program to Improve Plant Process Safety," *Chemical Engineering Progress (CEP),* vol. 107, pp. 48-52, 2011.

[14] J. A. Klein and S. Dean, "Develop a Loss-of-Containment Reduction Program," *CEP,* vol. 116, pp. 35-40, 2020.

[15] F. K. Bitar, D. Chadwick-Jones, M. Lawrie, M. Nazaruk and C. Boodhai, "Empirical Validation of Operating Discipline as a Leading Indicator of Safety Outputs and Plant Performance," *Safety Science,* vol. 104, pp. 144-156, 2018.

[16] U. S. Chemical Safety Board, "Refinery Explosion and Fire," Report No. 2005-04-I-TX, 2007.

[17] J. A. Baker and et al, "The Report of BP US Refineries Independent Safety Review Panel," 2007.

[18] T. Kletz, An Engineer's View of Human Error, 3rd Edition, CRC Press, 2001.

[19] J. Collins, Good to Great, HarperBusiness, 2001.

[20] J. Collins, Turning the Flywheel, HarperCollins, 2019.

[21] J. Clear, Atomic Habits, Avery, 2018.

[22] J. A. Klein, "Evaluating Operational Discipline in PSM Audits," in *Global Congress on Process Safety*, New Orleans, LA, 2008.

[23] J. A. Klein, "A Workshop for Evaluating and Improving Operational Discipline," in *Global Congress on Process Safety*, New Orleans, LA, 2008.

[24] A. Gawande, The Checklist Manifesto: How to Get Things Right, Picador, 2011.

[25] M. Buckingham and C. Coffman, First, Break All the Rules: What the World's Greatest Managers Do Differently, Simon & Schuster, 1999.

[26] Center for Chemical Process Safety, Essential Practices for Developing, Strengthening, and Implementing Process Safety Culture, John Wiley & Sons, 2018.