March 4, 2024

Dear DIERS Member,

The DIERS Operating Committee members are delighted to announce the publication of an enhanced strategic plan. The DIERS organization has evolved, since its formation in 1976 as an industry consortium, into its current structure as a technical entity under the auspices of the AIChE. The development of this plan is the first step towards realization of the DIERS vision "*to make the world a safer place as the leader in the design of safe and effective over-pressure protection, emergency relief and effluent handling systems.*"

A strength of the DIERS organization is its devoted membership. Numerous volunteers have enabled the success of key activities such as technical projects, education courses and technical meetings. Opportunities are also available for you to take part in an initiative to improve the organizational effectiveness and the focus on knowledge gaps within boundaries of the DIERS mission statement.

The enclosed strategic plan was carefully developed by the Operating Committee members and member volunteers. The DIERS vision and mission are provided first and then strategic pillars essential for DIERS success are enumerated. Those sections are followed by lists of stakeholders and DIERS technologies. The boundaries of DIERS mission can be restrictive or encompassing depending on the interpretation of the mission statement. Thus, a definition of the boundaries of the DIERS mission is provided. A SWOT (strengths – weaknesses – opportunities – threats) analysis and a knowledge gap analysis are provided to identify focus areas for improvement. Final sections include a vision for interfacing with other technical organizations, benefits of DIERS membership, and acknowledgements for contributions in developing the strategic plan.

One essential theme identified in the development of the strategic plan is the desire to enhance membership experiences. A few examples identified are to provide additional opportunities to develop less experienced engineers into subject matter experts (SMEs), provide opportunities for knowledge sharing with SMEs, enhance stakeholder communications, and improve member input in the technical program development. Additional ideas are found in the attached strategic plan.

Your feedback is critical to the success of the strategic planning and execution process. Please provide comments to Greg Hendrickson by email at GregHendrickson1954@gmail.com or by phone at 832-527-9129 by April 1, 2024. Greg will compile the comments and share the feedback with the Operating Committee for final consideration. More importantly, please communicate your desires to plan, lead or contribute to initiatives that enhance member experiences and/or influence the DIERS technical program. A break-out session at the upcoming virtual spring meeting will be provided to further discuss feedback received. We look forward to hearing from you.

With regards,

Harold Fisher, DIERS Chair

Greg Hendrickson, DIERS Secretary

The Design Institute for Emergency Relief Systems
2024 Strategic Plan
DIERS Operating Committee
Date: 2/25/2024, Rev: 0

Abstract

DIERS was formed in 1976 as an industry consortium with corporate sponsors and a sponsor funded project. Since then, DIERS has evolved into an AIChE technical entity with individual membership and with volunteer project leaders and committee members. Considering the evolution of DIERS, the Operating Committee embraced the opportunity to develop a strategic plan to focus activities towards achieving the DIERS purpose and aspirations. The vision, mission and strategic pillars for organizational sustainability are defined. Opportunities to improve organizational effectiveness and to close technical knowledge gaps within the boundaries of the mission are then considered. Finally, responsibilities of DIERS liaisons with standards writing organizations and benefits of DIERS membership are outlined.

1. Introduction

The Design Institute for Emergency Relief Systems (DIERS) was formed in 1976 as an industry consortium to develop technologies for the design of emergency relief systems, particularly for overpressure events involving two-phase vapor-liquid flow and runaway chemical reactions. Results of the original DIERS project include methods to predict the occurrence of two-phase vapor-liquid venting, vent sizing methods for two-phase vapor-liquid flashing flow, and calorimetry methods to determine the required venting rate during runaway chemical reactions. The DIERS consortium became the DIERS Users Group in 1985, with corporate representation in biannual meetings. The DIERS Users Group then became DIERS, a Technical Entity within the AIChE, with the membership structure changing from corporate membership to individual membership in 2020.

As DIERS evolved from an industry consortium with corporate sponsorship and a sponsor funded project to a Technical Entity with individual membership and volunteer led projects, the nature and the scope of projects also evolved. Volunteer champions (leaders) and project committee members are selected to define and execute new projects based on their interests and skills. Ideally, the scopes of new projects are within the boundaries of DIERS mission, address current knowledge gaps, and are interesting enough to attract volunteer project team members. One purpose of this document is to convey the DIERS mission and known knowledge gaps to improve technical project selection.

Not all DIERS projects are technical projects. Some projects are efforts to improve operational effectiveness, ensure financial sustainability, develop the next generation of pressure relief design subject matter experts (SMEs), and develop the next generation of DIERS leaders (succession planning). These projects are largely the responsibility of the Operating Committee members. A second purpose of this document is to define opportunities for operational improvements.

The DIERS **Vision** and **Mission** are reviewed and updated sections 2 and 3, respectively. The **DIERS Strategic Pillars** are discussed in section 4. The pillars comprise the essential elements for the sustainability of the organization and represent areas where resources should be focused. **Stakeholders** represent people or groups that can affect or be affected by the organization, and are listed in Section 5. A list of **Key DIERS Technologies,** developed since DIERS inception, are listed Section 6. These technologies provide the foundation upon which future improvements can be made. Sections 1 – 6 define the role of DIERS in the process safety space.

The interpretation of the DIERS mission is found in the **Discussion** in Section 7. This section provides a description of what technology areas are included within and excluded from DIERS purview. These boundaries define the technology space in which DIERS technical projects should focus. The **Strengths-Weaknesses-Opportunities-Threats (SWOT) Analysis** is provided in Section 8 to facilitate identification of operational (and some technical) improvements, and the list of **Gaps in Knowledge** in Section 9 is provided to facilitate selection of technical projects. Sections 7 – 9 facilitate identifying potential areas of improvement.

An element of the DIERS mission is to interface with other organizations. A list of members with **Responsibility for DIERS Representation with Other Organizations** is found in Section 10. Assuming the organization is successful, members should experience the **Benefits of DIERS Membership** found Section 11. Finally, **Acknowledgements** for input and reviews to the development of this document are found in Section 12.

2. Vision

The DIERS vision is to make the world a safer place as the leader in the design of safe and effective over-pressure protection, emergency relief and effluent handling systems.

3. Mission[1]

The mission of DIERS is to advance the practice of designing safe and effective emergency relief systems around the globe, particularly for multiphase systems concomitant with runaway chemical reactions, so as to reduce the frequency and potential consequences of overpressure incidents.

The objectives of DIERS, related to relief system design are:

- Maintain and upgrade the DIERS methodology,
- Identify knowledge gaps in emergency relief system design and evaluation,
- Address knowledge gaps by promoting and developing improved emergency relief system design and evaluation techniques,
- Provide opportunities for junior members to develop into relief system Subject Matter Experts (SMEs),
- Provide a forum for discussion and a mechanism for exchange of information regarding specific improvements, modifications, clarifications or corrections,
- Develop technical meeting programs, arrange and host the technical meetings,
- Promote and provide continuing education related to emergency relief systems,
- Provide outreach to industry, trade groups, government, academia, and the public to increase awareness of emergency relief system design,
- Share best practices related to emergency relief system design with industry, trade groups, government, and academia,
- Provide a mechanism for ongoing cooperative research and development, and

[1] Revisions from the 2020 DIERS bylaws are indicated in red font.

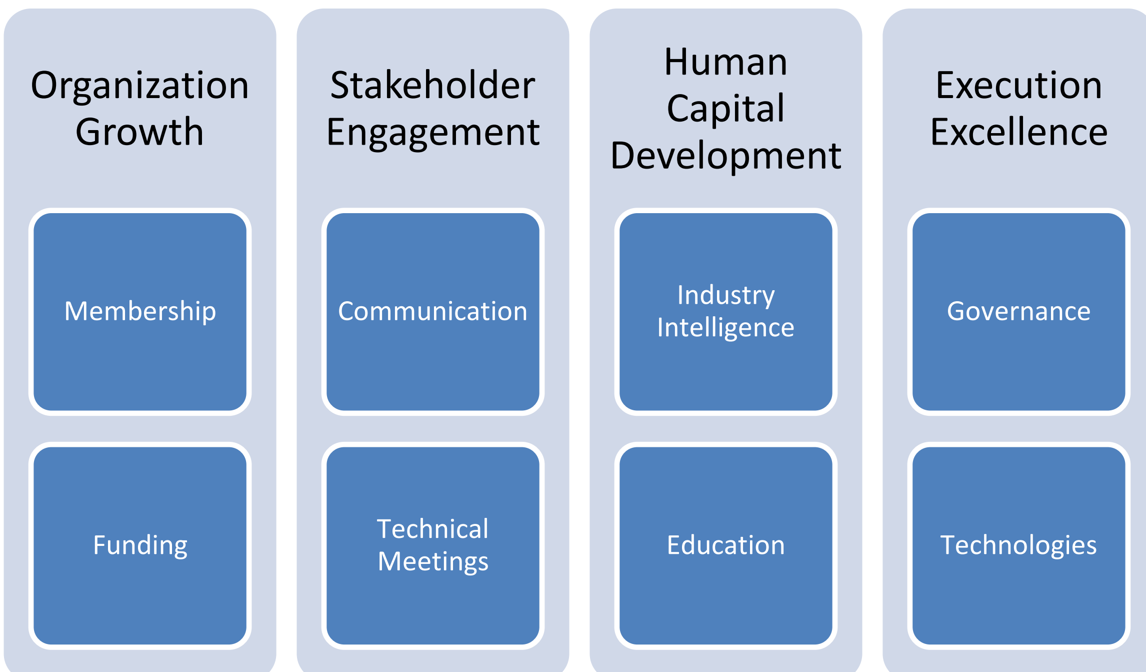
- Interface with and advise code- and standard-writing organizations on improvements in emergency relief system technology.

The sustainability of the DIERS organization is dependent upon technical excellence and effective succession planning to ensure future leaders are in place. Technical excellence is reflected in DIERS technical projects. Training and development of members for future leadership roles is provided by inclusion of members in planning and execution of DIERS activities.

4. DIERS Strategic Pillars

DIERS strategic pillars are key area of focus essential for the long-term sustainability of the organization. These pillars underpin the strategy and identify areas where resources should be allocated. The pillars are illustrated in Figure 1 and explained below.

Figure 1, DIERS Strategic Pillars



1.1Membership – The strength of DIERS is reflected by its membership. Members' experiences and skills provide a crucial role in supporting the mission. Members also provide human capital by volunteering for projects. Maintaining the current membership, recruiting new members, fostering volunteers, and developing new leaders are essential for DIERS viability.

1.2 Funding – DIERS technologies are developed using a volunteer projects-based approach and disseminated through technical meetings and DIERS education courses, which requires operational funds. Additionally, DIERS is required to pay an allocated portion of the AIChE overhead. Funding is primarily obtained through membership dues and technical meeting fees. Increasing income via increased stakeholder participation is the strategy for funding the organization. Corporate funding of special projects is not considered an element of the DIERS strategy[2].

2.1 Communication – Clear communication of the business value provided by DIERS to stakeholders and accurate dissemination of DIERS technologies underlies the success of the organization. Clear communication of the business value of DIERS contributions and accomplishments maintains stakeholders' engagement and encourages new members to join. Communication is primarily through the technical meetings, email, and websites.

2.2 Technical Meetings – Biannual technical meetings are the primary method of communication within the DIERS organization and subsequently for dissemination of DIERS technologies to stakeholders. The success of the technical meetings lies in the many contributions by a broad swath of the membership (and invited non-members) and members are encouraged to present at the meetings. Business and technical priorities of the DIERS organization are reflected in the meeting programs.

3.1 Industry Intelligence – Standards organizations, e.g., API, ISO, etc., recommend technologies that utilize and/or overlap with DIERS technologies. Monitoring of design methods recommended by other organizations and addressing them when they conflict with DIERS technologies as well as advocacy and advising of those organizations are fundamental roles of the DIERS organization. Technology monitoring and DIERS advocacy is primarily achieved by volunteer participation in industry and regulatory organizations.

3.2 Education – Continuous education of DIERS members is primarily provided through biannual meetings and of non-member stakeholders through the DIERS Basic and Advanced Emergency Relief System Design courses. Education of targeted stakeholders and the general-public is through participation in external conferences, external publications, and advertising.

4.1 Governance – The DIERS members act in a legal and ethical manner, guided by DIERS bylaws, AIChE Board guidance and applicable regulations. The Operating Committee provides oversite and controls of ethics and compliance activities. DIERS members and non-member technical meeting attendees are expected to follow the DIERS bylaws, the AIChE Code of Ethics and the AIChE Code of Conduct.

4.2 Technologies – DIERS members develop improved technologies using a project approach and promote them during the DIERS technical meetings. Project ideas may be submitted by members and/or generated during brainstorming sessions during the technical meetings. Proposed projects are prioritized considering stakeholder input and aligned with resources contributed by volunteers.

5. Stakeholders

Stakeholders are the DIERS sponsors (CCPS, AIChE) and current users of DIERS technologies including:

- Operating companies
- Engineering consulting companies
- Individuals
- Regulatory agencies
- Industry associations

[2] Sponsor funded projects have been discussed in the past, but have been removed from consideration.

- Educational institutions

6. Key DIERS Technologies

Key DIERS technologies[3] are the foundation upon which future improvements rest and include:

- Criteria for determining if single-phase or multiphase flow will occur during emergency venting scenarios (α versus ψ curves)
- A bench-scale adiabatic calorimeter to determine the source-term energy release rates for vapor systems and gas-generation rates for gassy systems under runaway reaction conditions (Vent Sizing Package, VSP2™)
- Calculation methods to scale design data obtained from laboratory calorimetry to commercial processes, i.e., Fauske relief sizing equations
- Calculation method to size emergency relief devices, i.e., an analytical solution of the isentropic nozzle equation using the Omega Method Correlation of State
- Software to size emergency relief systems, including:
    - SAFIRE (Systems Analysis for Integrated Relief Evaluation)
    - CCflow
    - TPHEM (Two-Phase Homogeneous Equilibrium Method)
    - COMFLOW (Compressible Flow)
    - SuperChems™ for DIERS
    - SuperChems™ for DIERS Lite
- Education courses that emphasize a precise rigorous code compliant approach to emergency relief system design and provide the skills to design vapor-liquid two-phase flow systems
    - Basic Emergency Relief System Design
    - Advanced Emergency Relief System Design
    - SuperChems™ for DIERS

7. Discussion

This section provides a discussion of what is included within and excluded from DIERS scope. The DIERS mission emphasizes the development and dissemination of technologies that embody the design of multiphase flow emergency relief systems concomitant with runaway chemical reactions. This statement is interpreted to mean technologies used to establish required relief rates (source terms), size and establish the mechanical integrity of components comprising emergency relief systems, and estimate consequences of relief events are within the boundaries of DIERS scope. Relief systems designed using DIERS methodologies will be in accordance with industry standards, such as API, ASME, ISO and NFPA standards. A more detailed definition of DIERS mission and description of its boundaries is:

- The term "multiphase flow" is meant to include simultaneous flow of up to four phases (Solid-Liquid-Liquid-Vapor)
- The term "multiphase flow" is also meant to include both choked flow (critical flow), e.g., within pressure relief devices, and subsonic flow (subcritical flow), e.g., within emergency relief system

[3] Copyrights and publication rights of the results of any projects sponsored through DIERS and any inventions and/or patents arising out projects sponsored by DIERS are assigned to the AIChE.

devices and piping. Methods to determine two-phase flow regime, liquid hold-up and pressure loss (both recoverable and non-recoverable) are included within DIERS purview. This definition of multiphase flow includes flow outside of containment, e.g., atmospheric dispersion of vapor clouds, by the necessity of venting to a safe location.

- The term “runaway reactions” is meant to include deflagrations inside containment (including gas-phase deflagrations and dust explosions). Including internal deflagrations within DIERS mission means sizing of deflagration vents is within DIERS purview. This definition excludes explosions outside of containment, e.g., vapor cloud explosions, and resulting overpressure effects.
- The term “emergency relief systems” is meant to include:
    - Every element that can be located within the flow path of the relieved fluid, such as pressure relief valves and similar devices (e.g., rupture disks and buckling pins), piping and piping elements (e.g., valves and fittings), vapor-liquid separators, vent stacks, and flares. By this definition, devices such as conservation vents, flame arrestors, and back flow preventers are within DIERS purview[4].
    - Methods and devices to protect the mechanical integrity of process equipment, e.g., vessel venting requirements based on estimated time to failure due to fire exposure
    - Methods and devices to safely dispose of the vented or flared materials. By this definition, considerations of venting to a safe location, and thus dispersion modeling and flame radiation modeling, are within DIERS purview.
- The term “emergency relief system design” is meant to include:
    - Specification of elements contained within an emergency relief system (and their flow order or connectivity or layout) such that the system performance is “safe and effective” according to requirements provided by regulations and industry standards. This definition includes specifying relieving pressure, flow capacity and mechanical design aspects, e.g., consideration of low temperature embrittlement, pressure relief valve chattering, and flow induced piping vibration. It also includes calculating reaction forces and transient fluid forces on relief system components. The interface between elements within DIERS purview and outside its purview is the pipe wall. Design of associated civil, structural, electrical, and instrumentation, etc. is not within DIERS purview.
    - Functional specification of alternative methods to prevent equipment overpressure (e.g., overpressure prevention by design) such as by dumping, flooding, or killing runaway chemical reactions. The definition of the “functional specification” of instrumented systems is to specify the design intent and performance requirements, such as flow capacity and response time. By this definition, the functional specification of, for example, safety instrumented systems and high integrity protection systems are within DIERS purview, but the detailed design of the instrumented systems to meet the specified safety integrity levels is not. Also, conducting the Layers of Protection Analysis (LOPA) and/or Quantitative Risk Analysis (QRA) to define Safety Integrity Level (SIL) are outside of DIERS purview.

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[4] Sometimes piping and equipment are part of both the process and the relief system. In these cases, the DIERS methods may be applied to process equipment during abnormal operation.

- Functional specification of systems to prevent loss of containment due to overtemperature events, e.g., vessel wall weakening during fire exposure such as, for example, vessel depressurization and water spray systems. This means that modeling of fires and their effects on process equipment is included within DIERS purview.

DIERS currently does not have a method to fund technical research projects. Efforts to complete DIERS projects will thus remain either volunteer or carried out within company initiatives. However, some selected compensation is considered appropriate, such as:

- Paying a nominal honorarium to project chairs upon project completion, e.g., on the order of $1,000 - $2,500.
- Paying a consulting fee to selected experts in the field for specific expertise needed to complete selected projects. These consultants would not necessarily need to be DIERS members.

DIERS sponsored volunteer technical projects primarily comprise the compilation, interpretation, and modeling of data available in the open literature. Thus, contributions to the art are primarily improved techniques and methods of designing emergency relief systems. However, DIERS members may participate in company sponsored research (as an employee) and contribute the resulting data and/or methods developed to interpret that data to DIERS[5].

8. Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis

The SWOT analysis is used to identify forces that enhance and diminish DIERS ability to accomplish its mission. This analysis provides areas of focus for the Operating Committee to allocate resources and to improve work processes.

<u>Strengths:</u> Experience, existing technologies, knowledge, existing tools, passion for the subject, limited network of experts, regular biannual technical meetings, AIChE/CCPS affiliation, few other existing organizations with this focused area of expertise[6], DIERS basic and advanced training courses, software (SAFIRE, CCflow, TPHEM, COMFLOW, SuperChems™ for DIERS and SuperChems™ for DIERS Lite)

<u>Weaknesses:</u> Marketing, execution, complex technologies/technobabble, missing unique value proposition, global name recognition (Africa, Asia-Pacific, Middle East), overconfident, lacks humility, ignoring big picture, too narrow of a focus, identification of project champions/leads, cogent business case for DIERS projects, communication to business leaders, insufficient general funds to close technical gaps, no formal work process for identifying and chartering projects, the website fails to communicate DIERS value (e.g., recent contributions and accomplishments), software (SAFIRE, CCflow, TPHEM, COMFLOW) user interface needs to be maintained for new versions of Windows (source code is unavailable), leadership focuses on complex solutions to unusual problems versus developing new SMEs to correctly apply existing technologies in real-world design situations, DIERS experts continue to seek mechanistic and analytical solutions to predict PRV stability[7], forum to develop SMEs and future DIERS leadership

[5] DIERS has no formal method for membership to review submitted data and/or methods, vote to accept or reject submitted results and/or methods, or formally recommend accepted data and/or methods as DIERS technologies.
[6] Another organization is the European DIERS User Group (EDUG)
[7] Real-world testing indicates this is stochastic or a function of system experience such as dirt, fouling, corrosion, or affected by complex piping.

Opportunities: Larger/new user base of Subject Matter Experts (SMEs), global name recognition (Africa, Asia-Pacific, Middle East), practical guidance and informational products, stakeholder focused communications, training junior engineers, business case communication (why DIERS), support from AIChE customer base, create a Reactive Hazards Evaluation and Calorimetry class, validate SuperChems™ for DIERS and SuperChems™ for DIERS Lite with results found in Adair and Fisher paper[8], provide DIERS fundamentals tutorials (refreshers) during technical meetings, provide continuity of technology awareness (through SME development)

Threats: Concern of becoming irrelevant by failing to innovate, loss of talent and aging experts, insufficient general funds to continue operating, cohesive direction, stagnant membership size, diminishing corporate participation (either by staff cuts or industry consolidation), aversion to alternative viewpoints or explanations, no formal method for accepting/rejecting new methodologies or technologies, advanced DIERS methods are beyond the reach of general practitioners without adequate training, absence of major technical challenges

9. Gaps in Knowledge

The intent of identifying gaps in knowledge is to determine what innovations are needed to advance the science (and the art) of multi-phase pressure relief, especially when runaway reactions contribute to the required relief rates. The list of knowledge gaps is useful to facilitate prioritization of future DIERS technical projects.

- Differences between US and European global relief standards
- Fluid mechanics of multiphase systems other than two-phase liquid-vapor systems, e.g., vapor-solid systems
- Limitations in liquid swell models used for sizing emergency relief systems, e.g., drift flux models that consider void fraction variation in vessels (particularly vessels with internals)
- Limitations in methods for characterizing reactivity for the purpose of relief sizing, e.g.
    - Decomposition reactions
    - Reactions that occur at high temperature (>400°C)
    - Rate measurements for solid systems (where adiabatic calorimetry has shortcomings)
    - Rate measurement for high reaction rate systems (where calorimetry temperature and/or pressure tracking are too slow)
    - Rate measurements for gas systems (where heat transfer rates to thermocouples are a limitation)
    - *In-situ* measurement of species concentrations in adiabatic calorimetry
- Limitations in the application of DIERS methodology to processes containing solids (surface reactions), e.g.
    - Trickle bed reactors
    - Gas phase fluidized bed reactors
- Limitations on modeling fire heat flux, e.g.
    - Fire temperature and emissivity
    - Engulfed in fire versus visible to fire
    - Heat flux with confined fires, e.g., with radiation reflected from walls
- Vessel rupture criteria during overtemperature events, e.g., hoop stress versus von Mises stress

[8] Adair, S.P. and Fisher, H.G., "Benchmarking of two-phase flow the safety relief valves and pipes," J. Loss Prev. Proc. Ind., 12(1999), 269-297

- PRV Stability for complex systems, e.g., parallel PRVs or PRVs mounted on piping
- Relief criteria for high temperature boiling materials, e.g., decomposition rate dependent
- Deflagration science applied to vent sizing methodology/software
- Guidelines for selecting atmospheric dispersion modeling methodology/software
- Flow induced vibration screening methodology/software
- Body bowl choking/restricted lift

10. Responsibility for DIERS Representation with Other Organizations

A key role within DIERS is to liaison with code- and standard-writing organizations and with other organizations focused on safety in the process industries. The expectation is for the DIERS representatives to provide periodic updates during the biannual technical meetings. Representation at other organizations is listed below.

Liaisons with Code- and Standard-Writing Organizations

- ASME – Danielle Mainiero-Cessna
- API – Georges Melhem
- ISO – Georges Melhem
- NFPA – ??
- ASTM Committee E27 on Hazard Potential of Chemicals - ??

Liaisons with Process Safety Organizations

- European DIERS Users Group (EDUG) – Georges Melhem
- European DIERS Users Group (EDUG) Joint Meeting – Ben Doup
- Center of Safety Excellence (CSE) – Georges Melhem
- Mary Kay O'Conner Process Safety Center (MKOPSC) – ??
- Purdue Process Safety Assurance Center (P2SAC) – Ben Doup
- Center for Chemical Process Safety (CCPS) – Georges Melhem

11. Benefits of DIERS Membership

DIERS provides access to methods and techniques beyond those provided by code- and standard-writing organizations, for example, methods to assess the impacts of non-ideal fluid properties and chemical reactions on emergency relief requirements, to select two-phase flow calculation methods when reactions are occurring (e.g., when the ω-method is not applicable), and to determine when vapor disengagement occurs during venting. Member benefits beyond access to advanced relief design methods include:

- Acquire skills to develop into a reactive relief system Subject Matter Expert (SME)
- Gain expertise by being part of vital exchanges with noted colleagues worldwide
- Participate in General Project Committees and contribute to the development of new relief system technologies (that may influence future standard and/or code revisions)
- Participate in round-robin calorimetry testing of reactive chemicals
- Participate in technical meetings to network with other technologists, acquire the latest technology developments, and learn about software updates in a timely manner

- Vote in DIERS elections to select DIERS leadership
- Participate in the development and updates of books, training materials, tools, and other products
- Access the DIERS website containing meeting minutes, meeting presentations and final reports of technical projects

12. Acknowledgements

Inputs and comments were provided by the DIERS Operating Committee (Harold Fisher, Georges Melhem, Greg Hendrickson, Wayne Chastain, Ben Doup, Passa Piland, Lisa Ruth)

Reviews and comments were provided by Todd Brandes, David Goetz, John Hauser, Marc Levin, Kerry McBride, Dan Smith

Inputs were compiled and edited by Greg Hendrickson