TECHNOLOGY AND THE ROLE OF THE NATIONAL ROOFING CONTRACTORS ASSOCIATION

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Roofing technology relates the practical application of physical, chemical and engineering sciences to the art of roofing. It provides information needed to keep material, design, maintenance and construction practices current with progress in science. Major technological changes occurred over the past decade. The shortfall associated with changing technologies is keeping practitioners informed about the risks and benefits of applying these technological advances in their businesses. The National Roofing Contractors Association (NRCA) recognizes its leadership role is first within the roofing industry. Thus, its purpose is to educate, act and provide information to allow its members to give consumers the best available technology. This paper describes NRCA's preparation for and reaction to the impact of massive technological changes. It focuses on environmental concerns, changing industry practices, new materials, research activities and government regulations as examples of NRCA's technical involvement in the roofing industry. It stresses NRCA's role as a catalyst rather than a primary research conductor. The paper describes NRCA's technical goals and objectives as stated in its long-range strategy plan. It dwells on NRCA's role in the future. These indicators are intended to convey a sense of what NRCA's technical role is within the international roofing community.

KEYWORDS

Activities, catalyst, change, communication, future, goals, international, long-range strategy plan, NRCA, objectives, role, roofing, science, technical, technology.

ROOFING TECHNOLOGY

Roofing technology relates the practical application of physical, engineering and chemical sciences to the art of roofing. This technology provides the various segments of the roofing industry with new and updated material, design, maintenance and construction practice information needed to produce and maintain better quality roofing systems. The ultimate benefits are longer roof performance for the consumer as well as higher profits for members of the construction team.

Technology remained at a low level in the roofing industry for a century or more. It began to slowly advance as the United States moved into the technological age following World War II. Consumer demands for better materials, improved design, and more efficient and labor saving construction practices provided impetus to increase the pace of roofing technology advancement.

Competition, innovation, profitability and problem solving provided the driving forces to further the introduction of new and improved technologies available to the roofing industry from the engineering and chemical sciences.

TECHNICAL CHANGE

Major changes occurred in the roofing industry over recent years. The introduction of the legion of different materials for roofing purposes during the 1970s and 1980s provides one example. Elastomeric, thermoplastic and polymer modification of asphalt are based on technologies that attained a prominent place in today's United States membrane marketplace. Technology provided innovative material and manufacturing processes to essentially revolutionize the roof thermal insulation market. As an example, according to the NRCA 1988-89 market survey, more than 50 percent of insulated low-sloped roofs, constructed in 1989, contained cellular plastic foam-type insulations.

Technology contributed to the design aspects of commercial roof construction. Mechanical attachment of insulation to metal decks became a common practice. Numerous types of metallic and plastic devices were introduced to facilitate positive membrane attachment as well as corrosion resistance to ensure durability. The two-layer requirement for insulating low-slope roofs became a recommended, and often specified, procedure. For the most part, these and other design changes were precipitated by performance problems experienced using the more conventional designs of the past, and the desire to increase thermal efficiency. Material requirements for fasteners, as corrosion resistance and holding power, relied on technology. Material compatibility and fastener spacing requirements became important issues in the design of commercial roofing systems.

New and changing technology impacted application methodology. New measurement techniques and field research investigations led to the updating of the equiviscous temperature (EVT) concept used for applying hot bitumens. Technology produced improved adhesives and unique application techniques for joining sheets of elastomeric single-ply membranes. Solvent and heat welding devices became common procedures for seaming laps of the thermoplastic materials. The polymer-modified bituminous products offered various methods for application depending on the polymer used to modify the asphalt. Heat fusing, hot or cold applied adhesives were options left up to the specifier or contractor. The health and safety of workers has always and remains a high priority. Consequently, health concerns such as the asbestos issue, coal tar and asphalt fume issues provided additional impetus to encourage research for new equipment and application techniques. Non-destructive evaluation (NDE) techniques became common practices for evaluating

the moisture content of low-slope roofing systems. These procedures were based directly on nuclear, dielectric and infrared technologies.

It is obvious that technology has provided major material, design, maintenance and application changes within the roofing industry over the past decade. The changes have impacted and, for the most part, benefitted all segments of the industry. Nonetheless, there are certainly shortfalls associated with changing roofing technologies. The major shortfall is keeping the practitioners informed about the risks and benefits of applying these technological advances in their businesses. Therefore, there is a need for a clearinghouse-type effort to keep informed and, when required, to evaluate the impact of the changes. This role has been assumed by the National Roofing Contractors Association (NRCA).

NATIONAL ROOFING CONTRACTORS ASSOCIATION (NRCA)

National Roofing Contractors Association represents the interests of the roof contracting industry. However, to adequately represent the professional contractor segment, the activities of the association extend much further. Consequently, as stated in its long-range strategy plan, a major goal of NRCA is to strive to provide leadership for the entire roofing industry and to assist the consumer to receive high quality and cost effective products and systems. NRCA has achieved that goal as the Association moves into the 1990s. It recognizes its leadership role is first within the roofing industry. In carrying out this role in the technological area, NRCA is dedicated to educating, acting and providing information to allow its members to give the consumer the best available technology commensurate with financial resources.

The question often arises as to the extent of NRCA's technical involvement. NRCA's essential role is that of a research catalyst and not a primary research conductor. The association's members are in an ideal position to identify the nature and magnitude of field problems. Once the problems are objectively identified, NRCA takes the responsibility to bring the problems and issues of concern to the industry table. Then it cooperates with and assists those who have legitimate interests, technical expertise and resources in addressing the issues and finding solutions to the problems.

NRCA'S TECHNOLOGY AND RESEARCH DEPARTMENT

The technology and research department, one of several service sections of NRCA, serves as the association's technical arm. It provides professional, technical and administrative supervision and coordination for NRCA technical programs and services in conjunction with the technical committees. It works with other NRCA service departments in carrying out these functions. The department maintains liaison with many outside groups to coordinate technical programs for the roofing industry. Technical aspects of research, standards, specifications and building codes are also concerns of the department.

The technical portion of NRCA's long-range strategy plan proposes the following goals and objectives for the technical and research department:

- NRCA continues to be the roofing industry's focal point for technical information on roofing materials and systems, and their performance.
  - NRCA disseminates technical information.
  - NRCA promotes the advancement of roofing science and technology.
  - NRCA stimulates the exchange of technical knowledge and technology in areas of research, performance testing and criteria development.
  - NRCA stimulates the exchange of technical knowledge and technology among the international roofing community.
  - NRCA develops a comprehensive body of technical knowledge and disseminates it to members and others through publications, conferences, symposia and other channels.
- NRCA continues to improve roof system performance.
  - NRCA identifies problems, investigates and proposes solutions involving design, materials, application, maintenance and performance of roofing systems.
  - NRCA communicates with manufacturers to review their published data prior to issuance to contractors.
  - NRCA suggests, sponsors and participates in research related to roof design, materials, application and maintenance.
  - NRCA develops and improves documents dealing with roof system design, materials, application, maintenance and performance.
  - NRCA acts as spokesman for the roofing contractor in the building code community.
  - NRCA encourages other organizations to publish specification guidance data consistent with NRCA recommendations.
- NRCA continues to be the industry spokesman for roofing contractors regarding technical matters.
  - NRCA establishes technical relationships between NRCA and material manufacturers.
  - NRCA establishes technical liaison between NRCA and other organizations involved in the roofing industry.
  - NRCA establishes technical communication between NRCA and affiliate contractor associations.
  - NRCA provides technical support to the National Roofing Legal Resource Center (NRLRC) and National Roofing Foundation (NRF).

IMPLEMENTATION OF NRCA'S TECHNICAL ROLE

The effort of NRCA is carried by a fine work balance between volunteers and staff acting within a committee structure. It often involves cooperative efforts with others in the industrial, governmental, academic and private segments of the building industry. Cooperative projects with industrial, manufacturers' associate and other contractor affiliate groups assist NRCA in carrying out its role in roofing technology.

During the 1970s and 1980s, technological change occurred in the roofing industry. Problem roofs, environmental concerns, governmental regulations, changing industry practices, research findings, international activities and a host of other factors precipitated the changes. In brief, NRCA is and has been involved. The illustrations which follow focus on NRCA's total involvement and response to technological changes as dictated by the goals and objectives

stated in its long-range strategy plan. This conveys a sense of NRCA's technical role.

The primary technical effort of NRCA is centered around problem avoidance in the performance of roofing systems. Consequently, its approach is to provide the designer and applicator with the best information that flows from the state-of-the-art technology.

RESPONDING TO EMERGENCIES

Within a span of two months in the fall of 1989, the United States was contending with two national disasters: Hurricane Hugo, in the Southeast, and a major earthquake in Northern California. Both contributed to an emerging role for NRCA in disaster assistance programs.

In South Carolina, NRCA was instrumental in creating a program of direct assistance to the most affected communities. Members from other parts of the country were flown in to assess damage, work with home and building owners, and establish training programs to fill the sudden demand for roofers.

More important, the association discovered that it could learn a lot about roof performance from the disasters. The extreme wind and structural forces placed on roofs in the two regions created an opportunity for examining roof design in those areas.

Further, an ongoing disaster response program was developed. In the future, the program will enable NRCA to assist its members when a disaster strikes, and to help affected communities to rebuild.

PROJECT PINPOINT

NRCA is the custodian of an annual survey of its 2,300 member contractors, aptly named "Project Pinpoint." It was initiated in 1974. The primary objective of the program is to provide an early warning procedure for the identification of problems. Once identified, the problems may be addressed and eliminated before they reach epidemic proportions. Project Pinpoint also provides information on trends and developments in material, construction and design information on low-slope roofing in the United States. A 1989 NRCA technical report gives a comprehensive description of Project Pinpoint's scope, operation and limitations.[1]

The data received indicate the frequency of problem occurrence. To supplement the problem information, NRCA obtains data on design, material and application parameters. NRCA's computer processing capability combined with some 260,000 data points collected on 13,000 roofing projects presently in the data bank, reflect an information source unlike any other in the world.

Data are selected from the 1989 returns to illustrate how the analysis of these data are used to indicate the five more common problems the respondents reported for the more commonly used roof membrane systems.

Tables 1, 2, 3 and 4 illustrate problems reported for 900 roofs protected with bituminous built-up, polymer-modified, elastomeric and thermoplastic membranes. The values are expressed as a percent of the total number of problems reported for each generic membrane material type. For example, blistering, splitting and ridging lead in the built-up category. Seam defects, puncture/tear and shrinkage are the three highest for the rubber-like membrane types. In fact, seam defects comprise 50 percent of the problems reported with EPDM and other rubber membranes. Polymer-modified bitumens rank high in seam deficiencies with nearly 36 percent of problems reported for these materials. Membrane shrinkage and material embrittlement along with puncture/tear defects account for a large percentage of problems for thermoplastic membranes. In brief, these examples show that Project Pinpoint data have the potential to reveal the strengths and weaknesses of the various membrane materials as well as other components of the roofing system. The designer, manufacturer, applicator and researcher profit from this information. Once problems are identified, ways and means are explored to reduce or avoid the incidence of specific problem areas.

WORKING WITH MANUFACTURERS

NRCA's principal focus is and always will be to serve its roofing contractor members. Nonetheless, the association has been successful in solving industry problems through cooperative efforts with manufacturers of roofing materials.

The "specification review" process is an excellent example of this cooperation. The process is an undertaking whereby NRCA offers suggestions to manufacturers for improving their specification manuals, on an individual basis.

To date, several manuals have been reviewed. Without exception, NRCA's suggestions have been incorporated. Principally, these fall into two broad categories:

- To clearly define contractor's responsibilities, as opposed to designer's and owner's responsibilities.
- To be sure the contractor's responsibilities are reasonable, and reasonably spelled out.

INTERNATIONAL TECHNOLOGY

Many of the roofing technologies of the 1970s and 1980s originated in Western Europe and imported into the United States. Polymer modification of asphalts and the utilization of thermoplastic polymers for the production of roofing membranes exemplify the application of European technology. NRCA expressed concern that the United States lacked test methods, criteria and standards to assure the quality of the materials its members were applying in the marketplace. This concern led to the formation of an international committee on elastomeric, thermoplastic and polymer-modified bitumen roof membrane materials.

In 1983, under NRCA's leadership, an international group of roofing technologists from 18 nations convened in Washington, D.C. under the auspices of RILEM and CIB.* A test protocol was developed to evaluate and characterize generic "single-ply" roof membrane materials. The committee's 1988[2] report identified available test methodology as reported in the 1990 issue of NRCA's *International Journal of Roofing Technology*.[3] Further, the committee defined research needs to develop test methods and performance criteria for these products. The RILEM/CIB activity contributed to the current effort in Europe to develop roofing standards and regulations for use in the new European community in 1992. Coordinated and complementary research activities in laboratories around the world also resulted. For example, the application of thermal analysis, cyclic fatigue, strain-

**RILEM—International Union of Testing and Research Laboratories for Materials and Structures. CIB—International Council for Building Research Studies and Documentation.*

energy, puncture and accelerated aging procedures to measure roof membrane performance are programs currently under way.

ENVIRONMENTAL CONCERNS

Environmental concerns of the 1980s impacted the roofing industry. Research and technology played a key role and NRCA was directly involved. The deleterious effect of chlorofluorocarbon (CFC) gases on the atmosphere's ozone layer resulted in a planned reduction in the use of these gases as dictated by the Montreal Protocol. NRCA joined SPI, PIMA, DOE and EPA** in bringing together leaders from raw material manufacturing companies, foam producers, product end users, and two government agencies in a search for alternative gases to foam polyisocyanurate roof insulations. A major cooperative industry-government research program was initiated to evaluate several hydrochlorofluorocarbons for their suitability as blowing agents in boardstock insulations. Specifically, HCFC-123, HCFC-141b and two blends of HCFC-123 and HCFC-141b were selected as potential alternatives for the current industry standard CFC-11. The study, involving several laboratories, investigated thermal and mechanical properties of insulating materials foamed with alternate gases. NRCA, representing the end user, needed assurance that the new materials will have the same or better mechanical longevity as those foamed with the CFC-11 gas. Hence, in cooperation with Oak Ridge National Laboratory (ORNL), NRCA provided the leadership in design and construction of the Roof Mechanical Properties Research Apparatus (RMPRA) at ONRL for in-service testing of mechanical characteristics.

HEALTH AND SAFETY

The National Institute for Occupational Safety and Health (NIOSH) published results of a carcinogenicity test of fumes from roofing asphalts and coal tar pitch generated at high temperatures. The fume condensates produced skin cancers when applied to the backs of mice. In December 1989, NIOSH released the results of a second study basically confirming the 1981 results.[4] The threat of OSHA regulations on allowable human exposure levels to asphalt fumes may negatively impact the bituminous segment of the roofing industry. NRCA, like others involved in the manufacture and application of asphalt, has a primary interest of furthering the understanding of potential adverse effects and developing recommendations for ensuring that asphalts be handled safely. NRCA has joined with interested organizations to carry out a multidisciplinary research effort under the direction of an industry oversight committee.*** The research involves experts in areas of chemistry, toxicology and epidemiology. These task forces are working together in furthering the understanding of potential adverse health effects of asphalt fumes on humans. A further objective of the joint committee is to develop appropriate recommendations for work practices to insure that asphalts are produced and used safely.

**SPI—Society of the Plastics Industry, PIMA—Polyisocyanurate Insulation Manufacturer's Association, DOE—Department of Energy, EPA—Environmental Protection Agency.

***The committee includes representatives from Asphalt Roofing Manufacturers Association (ARMA), Asphalt Institute (AI) and National Roofing Contractors Association (NRCA).

SCIENCE, TECHNOLOGY AND EDUCATION

NRCA is not content to be restricted as an active participant in practical, applied research. The association is also concerned about the future of roofing science and technology. Since 1983, NRCA has been active in providing financing and technical support to graduate students pursuing advanced degrees related to roofing technology. In 1984, NRCA through a research grant of the National Roofing Foundation sponsored a doctoral candidate at Clemson University in South Carolina. The research addressed the fundamental characterization of mechanical behavior of both APP and SBS polymer modified bitumen specimens. The principal emphasis was placed on thermal loading and elongation at low temperatures. The student's doctoral dissertation[5] was the basis for a paper read at the 1985 NRCA/NBS Second International Symposium on Roofing Technology.

In 1988, NRCA in cooperation with the National Institute of Standards and Technology (NIST) and the Johns Hopkins University sponsored a graduate student as an NRCA research associate at NIST. It was a unique program in that it involved industry, government and academia participation in a roofing research project. Recommendations of the RILEM/CIB international roofing committee provided the basis for the research effort. The investigation centered around the application of thermal analytical methods in characterizing roof membrane materials and the changes that occur on aging. The student completed all the requirements for the master of science degree with the submission of an essay on the characterization of EPDM membranes using thermal analytical techniques.[6]

NRCA continues to contribute financial and technical support, along with the Johns Hopkins University and NIST, for the student conducting research toward a doctor of philosophy degree. The research involves the characterization of mechanical properties of foamed, polymeric cellular roof insulations. It is a current and appropriate subject in as much as the roofing industry seeks alternative gases replacing the CFC and, eventually, the HCFC gases. Further, the project will satisfy the requirements of each of the sponsoring organizations. NRCA is particularly pleased that a successful project will lead to development of performance criteria for the mechanical properties of these materials.

RESEARCH AND TESTING

Research is problem driven. The roofing industry is problem prone. Once problems are identified, research may be required to seek solutions. Experience indicates the NRCA has often taken the lead to carry out or cosponsor research efforts to improve roof system performance. In brief, NRCA is involved. Examples of NRCA's involvement are legion. Several are listed here.

- The modernization of the equiviscous temperature (EVT) concept relating to asphalts and coal tar products called for two joint NRCA/industry programs.[7,8]
- Blistering and moisture-related problems resulted in a field study of the application effects of hot asphalt on roof insulations.[9]
- Complaints received from members about problems experienced over cellular insulations precipitated a field study. The program involved crushing, membrane adhe-

sion and uplift tests on phenolic and polyisocyanurate foam roof insulations.[10]

- The SPI, MRCA (Midwest Roofing Contractors Association) and NRCA cosponsored a project to address concerns about the design and application parameters of expanded polystyrene insulation used in built-up and single-ply roofing systems.[11]
- Mechanical fastening became the most common method for securing insulations and membrane to the structural deck. Potential for problems caused by corrosion and other deficiencies of some fasteners became of serious concern to all segments of the roofing industry. As a result, NRCA conducted a study gathering performance experience, research and technical information on fasteners. Guidelines were prepared to assist design professionals, contractors and owners when problems are encountered.[12]

TECHNOLOGY TRANSFER

NRCA's role in roofing technology is exemplified by the multifarious activities of staff and volunteers as indicated previously. This paper has related how data are collected and analyzed into practical and useful information for NRCA members in particular, and the entire roofing industry in general. However, the job is not accomplished until the information is applied by the day to day roofing practitioner. The challenge for NRCA is to communicate the information to designers, manufacturers, contractors and owners. In addition, it is essential that current information be communicated to the specification, standard and building code generators of the construction community.

NRCA communicates technical information through the activities of both volunteer members and staff. New and updated technical knowledge is an important ingredient to keep the major publications of NRCA current. The *NRCA Roofing and Waterproofing Manual* exemplifies the state-of-the-art design and application practices used in the United States roofing industry. It is continually updated with current information and reissued every five years. Another example is the *NRCA Roofing Materials Guide.* It provides the industry with test data and standards information on literally hundreds of products of membranes, insulations, fasteners and metal roofing materials. It is updated on an annual basis. Technical reports on special projects are prepared and made available to members and others. They provide conclusions and recommendations based on the findings of the projects.

NRCA's *International Journal of Roofing Technology* is devoted exclusively to scientific and technical issues of the roofing industry. It provides a forum for the exchange of technical information among all segments of the international roofing community. Its contents are directed toward the technologist and non-technologist alike.

Professional Roofing magazine, NRCA's monthly publication, keeps readers current with its technical articles and columns contributed by professional writers, staff and volunteers.

NRCA sponsored symposia, conferences, seminars, round tables and workshops are important media for communicating technical information. NRCA and the National Bureau of Standards (now the National Institute of Standards and Technology) initiated a series of biennial technical conferences on roofing technology in 1969. In addition, international symposia on roofing technology are held approximately every four years involving multiple sponsors. NRCA is also involved with special workshops addressing current issues such as wind engineering and mathematical modeling.

NRCA AND ROOFING TECHNOLOGY: THE FUTURE

NRCA's role, then, is well established in the field of roofing technology. However, the industry is far from static and it may be useful to see how NRCA's role may develop in the future.

The same model can be used for the framework of that development. That is, NRCA can be seen as the catalyst for research, a central source for information and a body for technical transfer. It is not hard to imagine NRCA's involvement in any of the following areas:

- Electronic Information Exchange—Data collected through project pinpoint is especially suited to the electronic medium. It could be formatted so that the information could be made available via computer networking.
- Monitoring Field Experience—It is understood that roofing technology relies as much on field experience as laboratory work. Then, it follows that the proper collection of field information, and its quick dissemination, will ultimately benefit the industry. Electronic media may enable contractors to share their experiences rapidly, and thereby help to prevent the catastrophes the industry dreads.
- Assessing New Products—Again, it is the expertise in field experience that is NRCA's unique contribution to roofing technology. Working with Oak Ridge National Laboratory and others, NRCA has learned the true advantages of assessing product performance in the field prior to introduction into the marketplace, creating a model that has obvious ramifications for the future.
- Communicating with Our Customers—Perhaps the greatest service NRCA can offer to the industry is to reinforce the importance of roofing technology, especially to those unfamiliar with it. Potential audiences include building owners, designers and specifiers, and government agencies. Proper technology is a part of the quality assurance process, and is incumbent upon NRCA to deliver that message to its industry customers.
- Acting As the Catalyst—If technology is to advance,it will do so with constant and improving communication among all affected parties. Symposia, technical journals, convention programs and liaison activities with other segments of the industry all serve to improve industry communication. It is apparent that there is still much to improve.
- Stimulating International Exchange—Roofing technology, like all technology, no longer knows national boundaries. There is no clearer mandate for NRCA's future than to insure that technologists from all countries work toward the common objective of improved roofing performance.
- Disaster Response—The disaster response program will be expanded to assist NRCA members and affected com-

munities when disaster strikes and involves roof damage and problems.

SUMMARY AND COMMENT

Technology plays an essential role in enabling NRCA to provide information, take action, educate and conduct programs that will enhance the business interests of NRCA members as directed in the mission statement. Providing services based on current technology improves the professionalism and business interest of the informed roofing contractor. Technological activities complement the activities of other NRCA groups in amplifying NRCA's leadership and that of its members in industry matters. The sharing of technical knowledge developed from NRCA members and numerous programs improves the understanding of the design professional, manufacturers and owners concerning the roofing contractor. Good technology increases NRCA's position with government and other groups in the private sector. Finally, the end result is for the betterment of the entire roofing industry.

This paper has stressed that NRCA is not, per se, a research conductor. However, with over 3,000 members, it is in an ideal position to act as catalyst for the employment of its technical resources to encourage research to address problems and issues of concern to the roofing industry.

This paper described examples of NRCA's activities that exemplify its role in roofing technology. The paper gives NRCA's preparation for and reaction to the impact of massive technological changes that occurred over the past two decades. It has focused on environmental concerns, changing industry practices, new materials, research issues, international concerns and government regulations as the movers and shakers of NRCA's technical involvement. It addressed NRCA's technical goals and objectives as stated in the long-range strategy plan. It presented information to convey a sense of what NRCA's technical role is about within the international roofing community.

NRCA's role is well established in the field of roofing technology. As experience has shown over the past two decades, the roofing industry is far from static. Therefore, NRCA, if it is to continue its leadership role, must strive to be dynamic in applying the current technologies in such areas as communication, environment, health, safety and in roofing performance. The paper has touched on several areas that NRCA's involvement may be useful in assisting the industry to grow and prosper in the future. In sum, NRCA should be envisaged as the catalyst for research, a central source for information and a body for technology transfer.

In conclusion, NRCA has been in the past and will continue in the future to be involved in roofing technology.

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Bituminous Built-Up Roofs		
Ranking	**Problem Type**	**% of Problems***
1	Blistering	24%
2	Splitting	22%
3	Ridging	18%
4	Slippage	6%
5	Wind Related	3%
		*does not add to 100%

Table 1 Five most common problems reported for bituminous built-up roofs.

Polymer Modified Bituminous Membrane Roofs		
Ranking	**Problem Type**	**% of Problems***
1	Seam Defects	36%
2	Shrinkage	11%
3	Blistering	10%
4	Embrittlement	8%
5	Wind Related	3%
		*does not add to 100%

Table 2 Five most common problems reported for polymer modified bituminous membrane roofs.

Elastomeric (EPDM) Membrane Roofs		
Ranking	**Problem Type**	**% of Problems***
1	Seam Defects	50%
2	Puncture/Tear	21%
3	Shrinkage	13%
4	Wind Related	10%
5	Blistering	5%
		*does not add to 100%

Table 3 Five most common problems reported for elastomeric (EPDM) membrane roofs.

Thermpolastic (PVC) Membrane Roofs		
Ranking	**Problem Type**	**% of Problems**
1	Shrinkage	42%
2	Embrittlement	29%
3	Puncture/Tear	17%
4	Seam Defects	9%
5	Wind Related	3%

Table 4 *Five most common problems reported for thermoplastic (PVC) membrane roofs.*