Baseline Safety Considerations for Solar Roof Laboratory

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Context

Research in solar thermal energy carries significant safety risk to the researchers and also to others in the vicinity. The SU solar roof laboratory is situated in a relatively high population area with engineering faculty buildings that have a direct line of sight to the laboratory. This document forms a draft of the foundational safety risks and recommendations for use of the laboratory. Any experiment on the solar roof laboratory must have a safety plan that a) complies with the M&M safety rules b) recognizes and addresses the safety items in this document and c) specifically addresses safety requirements of the experiment.

Categories

In addition to the rules outlined in the M&M safety document, the following pertain to the solar roof laboratory. For instance, this document does not specifically state the need for a minimum of two people to be present in the lab as this is already documented in the overall safety rules.

Access

Only people directly involved with solar research, staff of M&M and their guests may access the solar roof laboratory.

Rooftop

- The rooftop is at a 3rd floor level – about 7m high. This is a safety risk for both falling and for dropping objects onto people below. Do not place anything on the walls as items can fall and injure somebody on the ground floor. Rails are in place to address this risk but vigilance is still needed. No running and irresponsible behavior is permitted (for obvious reasons).
- No heavy apparatus may be used on the solar roof lab. The limit is 500 kg/m^2 or in the event of a point load spread the load in a suitable way. Items that may fall into this category include
    - Complete scaled CSP plants
    - Thermal energy storage systems
    - Large water tanks

Direct sun exposure

- Notwithstanding concentrated sunlight, the sunlight intensity and temperature on the solar roof laboratory is potentially harmful to skin and eyes. It is a requirement that brim hats, sun screen and sun glasses be used when spending significant time on the roof.

Optical

- Exposure to concentrated sunlight can be immediately harmful. It can cause blindness and severe burning. All necessary precautions are to be followed to avoid exposure of any level of solar concentration.
- Fixed length focal points as encountered in parabolic dishes and parabolic troughs typically have short focal lengths and are only harmful in the immediate vicinity of the concentrator. Operation of these devices:
    - Keep covered or out of direct sun when not used or during setup
    - Preferably have a physical marker indicating the focal area and do not place limbs, etc., in the area when operating.
    - Note that a poor parabolic dish can have a focal point temperature exceeding 1,000 °C; a good dish can exceed 2,500 °C.
    - Provided that these concentrators don't have the ability to become flat, they pose no risk at a long distance--much like a curved motor vehicle window does not reflect much light to people in other cars. Thus they pose no risk to people in adjacent buildings.
- Flat or near flat reflectors such as used in central receiver plants or linear Fresnel plants pose very low risk at a distance close to any one reflector surface and it is generally safe to move and work in the vicinity of the reflectors while in operation. <u>These surfaces pose a significant and serious risk to adjacent buildings and distance observers</u>. Specific safety considerations:
    - Working with a <u>single</u> flat reflective surface does not pose a high risk to burning but it does have close to the same intensity as direct sun at any distance, thus there is a risk to eye damage. For this reason it is not permissible to use adjacent buildings as optical targets without express permission from the building owners. It is preferable that building walls not be used under any circumstance. Optical testing can only be done on surfaces approved by STERG and preferably only on optical targets specifically rigged for this purpose. Under unusual conditions, a near flat single surface will act as a concentrator with long focal distance, thus exceeding the direct sun intensity.
    - Working with multiple flat (or near flat) reflective surfaces will result in solar concentrations near the focal distance that exceeds the safe exposure to people for any length of time. Experimental systems with multiple flat or near flat surfaces must be supervised at all times and sufficient safety warnings need to be present for the testing. Under no circumstances may concentrated light be permitted to strike any surface other than the high flux optical target. The ability to rapidly de-focus the reflectors must be demonstrated prior to testing. If long term operation of a test is required for which supervision is not feasible, a specific test plan must be approved by STERG and the M&M department.
- Receivers and targets are the final destination for optical energy. These also have specific safety requirements
    - Optical targets will usually be light in colour for the ability to test optics and thus will reflect a high amount of light but in a diffuse manner. Targets are not to be used with high concentration ratios and the target needs to be flame retardant. The diffuse nature of light will make the light visible to people in surrounding buildings. It

is the responsibility of the test personnel to ensure that the light intensity does not exceed comfort levels for eye sight.

- Receiver targets need to absorb a high portion of light, but even so will appear very bright if the concentration level is high. Thus they have the same requirement as optical targets. Receiver targets will operate at high temperatures and must not be constructed of any combustible materials.
- During operation no person may be in the vicinity of a target. A suitable method to prevent access is required.

Thermal

Some thermal considerations are mentioned above, particularly regarding optical and receiver targets. In general, the optical destination (collector, receiver, target) will be at an elevated temperature. Handling of such surfaces or objects must be done in accordance with the safety instructions for the test. Some items in this category:

- Solar water heating
- Small solar thermal storage systems

Thermodynamic

In the event that a thermodynamic process occurs, such as the heating of a fluid in pipes, a variety of safety considerations need to be taken into account.

- As per thermal, the temperature of the working fluid or heat transfer fluid can be dangerous.
- Compressible fluids or phase change fluids may or will build up pressure. Such experiments need to comply with all necessary codes and will require appropriate approval. The risks associated with such experiments include the harmful consequences of a release of both kinetic and thermal energy (such as a pipe bursting which releases shrapnel and steam). To illustrate how easily this can happen, water turns to steam at 100°C and 1bar and the volume increases roughly a thousand fold (1m ℓ water = 1ℓ steam) in an open system. Such an outcome must be considered in closed-loop systems.