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Roof Fasteners for Metal Deck Roofing Systems: Energy Impact on Reroofing and Recover Scenarios

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Abstract

During roof construction, although necessary codes may be complied with, several thermal bridges and/or other anomalies are commonplace that may affect envelope thermal effectiveness. Typically, while reroofing metal deck systems, old fasteners are removed and the new, mechanically fastened ones do not use the same holes created by the old fasteners. Reroofing occurs an average of three times during the useful life of a building, and this causes severe impacts to heat and moisture transfer that are detrimental to roof insulation and, thereby, overall energy use. Using THERM, this paper quantifies the energy impacts of roof fasteners for the most commonly used metal deck roofing system configuration for reroofing and re-cover. This paper will conclude with potential solutions to reduce energy impacts.

Speakers

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Roof Fasteners for Metal Deck Roofing Systems: Energy Impact on Reroofing and Recover Scenarios

1. BACKGROUND

The roof is a building's first line of defense from natural hazards and is a critical component of the building envelope. The typical low-slope roof assembly, from the structural deck up, consists of the following components:

- Structural roof deck
- Insulation, including such rigid foam types as polyisocyanurate, expanded polystyrene, and extruded polystyrene or lightweight insulating concrete
- Fasteners and/or adhesives, including mechanical fasteners, low-rise adhesives, hot asphalt, or cold-applied liquid adhesives
- Cover board
- A membrane system, asphalt-based systems such as built-up roof or modified-bitumen system, or single-ply systems such as thermoplastic membranes and thermoset membranes.

Wind uplift pressures vary in field, perimeter, and corner zones of a typical low-slope roof. Properly designed roof insulation plays a key role in energy efficiency. Heat energy flows from a warmer to a cooler space. In a conditioned space, a significant amount of heat can enter a building through an inadequately insulated roof assembly during the cooling season (summer). Similarly, heat can leave a building through an imperfectly insulated roof assembly during the heating season (winter). Also, even with a perfectly insulated assembly, there will be heat flow through the assembly.

Although several building energy standards exist (more specifically, the American Society of Heating, Refrigeration, and Air-Conditioning Engineers' [ASHRAE's] 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings* [ASHRAE 2010]), the building envelope section entirely focuses on R-value insulation requirements for various U.S. climatic zones and leaves out other components that may potentially create thermal bridges, (e.g., metal fasteners, plates, etc.). In other words, despite the importance of insulation, the recommendation of using minimum R-value alone may not ensure that the roof assembly will perform effectively. Not accounting for thermal bridges due to fasteners or insulation board joints results in actual efficiency being less than that of the designed efficiency, but this does not mean that the assembly will not perform effectively due to the interference of other components unless adequately tested and evaluated for energy loss. Particularly, during actual roof construction, although the assembly may comply with necessary energy codes, several thermal bridges and/or other anomalies that may affect envelope effectiveness are commonplace. Typically, roof fasteners in metal deck roofing systems penetrate through several layers to connect to the metal deck in order to prevent wind uplift.

The most commonly used definitions for roofing activities are "reroofing," "roof re-cover," and "roof replacement." The Florida Building Code 1502.1 (FBC 2010) describes these as follows: Reroofing is the process of recovering or replacing an existing roof covering; roof re-cover is the process of

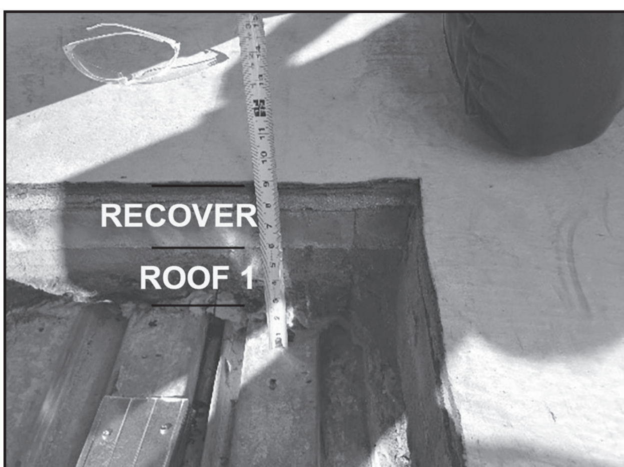


Figure 2 – Roof re-cover scenario where an existing roof is removed and the metal deck receives a new mechanically fastened roofing system.

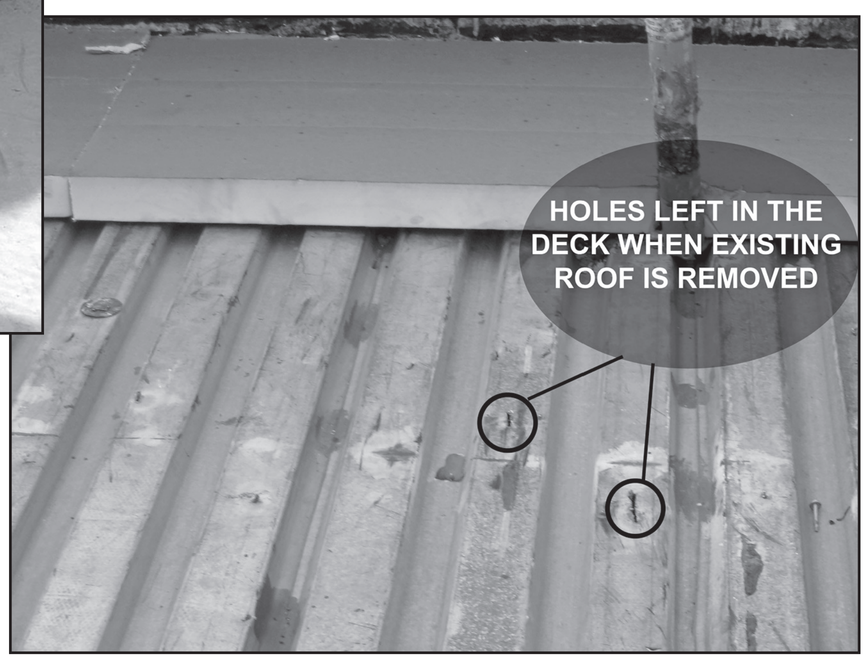


Figure 1 – Reroofing scenario where an existing roof assembly receives new roof assembly without any tear-off.

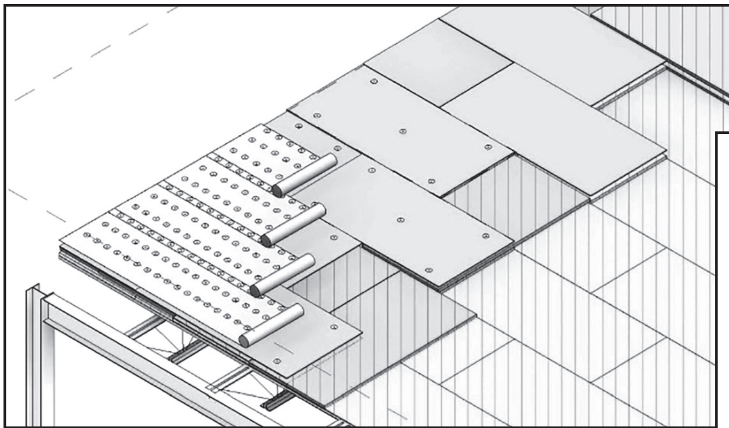


Figure 3 – Axonometric view (types 1A, 1B, 1C).

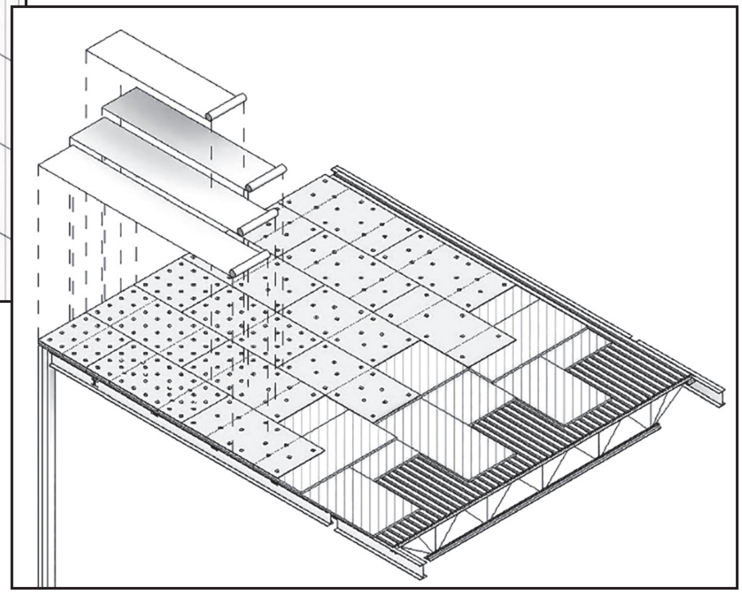


Figure 4 – Axonometric view (type 2).

installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering; and roof replacement is the process of removing the existing roof covering, repairing any damaged substrate, and installing a new roof covering. In addition to codes, commercial insurers develop guidelines for roof assembly systems. Among others, Factory Mutual Global (FMG), a commercial insurer, is a leader in certification and approval of roofing products and roof assemblies (Factory Mutual 2015).

Figures 1 and *2* are reroofing and roof recover site photographs. In a reroofing scenario, as the existing roof assembly is removed, the removal process leaves holes in the metal deck. During this process, there are instances where the existing fastener heads are cut off and the shank is left behind in the metal deck. Particularly if such reroofing occurs on an average of three times during the useful life of a building, per ASTM E2921.13, Section 6.1.4 (2013), there may be thermal impacts due to thermal bridges that may be detrimental to roof assembly and, thereby, overall energy use. Among others, one of the objectives of this project is to study these impacts.

Burch et al. (1986) used a finite-difference model to analyze the overall thermal resistance in metal and wood deck roofs for insulation thickness ranging from 1 to 6 in. However, existing research in analyzing roof assemblies does not reflect the recent developments in materials used for roofing insulation, steel fasteners, etc., that also comply with commercial insurers. Moreover, this research does not provide the necessary insight into behavior across all eight climatic zones (i.e., representative cities of these climatic zones). To the best of the authors' knowledge, at this time, no study exists specifically analyzing thermal loss of roof assembly systems from metal fasteners.

To analyze the energy loss due to thermal bridges from the presence of metal fasteners in roof assemblies, we employ THERM software (2015). THERM is a finite-element, two-dimensional heat transfer analysis tool that uses a steady-state conduction algorithm, CONRAD (Curcija et al., 1995). THERM's calculation routine evaluates conduction and radiation from first principles (Huizenga et al., 1999). THERM has been widely used in the field of envelope heat transfer analysis. To give an example, Mahabir and Srinivasan (2012) developed discrepancies in fenestration heat transfer characteristics owing to window-wall interface interactions.

This paper discusses the energy impacts of roof fasteners for metal deck roofing systems during reroofing and re-cover scenarios. The paper is organized as follows: Section 2 discusses the descriptions of metal deck roofing systems used in this analysis, while Section 3 lists the heat transfer parameters and other assumptions used in the analysis. Section 4 provides results and observations of simulations conducted on the reroofing and roof recover assembly systems.

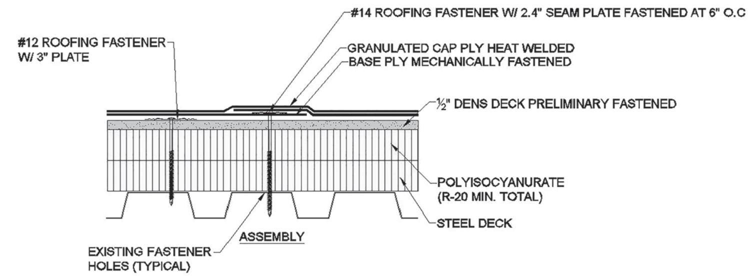
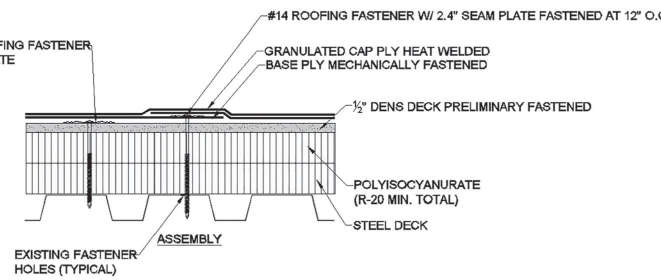
2. DESCRIPTIONS OF METAL DECK ROOFING SYSTEMS

Reroofing Assembly Systems

For the purposes of this study, we have identified four reroofing assembly systems.

- Type 1 refers to insulation and cover board that are preliminary fastened per manufacturer's requirements, and the base sheet is mechanically fastened. Within this general roof assembly system, we have identified three subtypes (types 1A, 1B, and 1C) based on fastener spacing, (*Figure 3*).
- Type 2 refers to mechanically fastened cover board and insulation, base ply and cap sheet adhered, *Figure 4*.
- Type 3 refers to mechanically fastened cover board over metal deck; base ply fully adhered over cover board; and insulation and roofing membrane, fully adhered.
- Type 4 refers to insulation mechanically fastened to metal deck and single ply attached using the electromagnetic induction welding method. Within this general roof assembly system, we have identified three subtypes (types 4A, 4B, and 4C) based on the arrangement of insulation.

See *Appendix A* for a detailed description of thermal barrier/cover board, vapor/air barrier, insulation, cover board, and roof membrane of each of these roof assemblies. *Table 1* lists reroofing assembly types, fastening patterns, and sections. Although nine roof assemblies are shown in this table, only six were analyzed for this paper. The remaining scenarios (reroofing types 2, 4B, and 4C, and re-cover type 1) are currently under investigation.

<table>
<tr><th>Type</th><th>Fastening Pattern</th><th>Section</th></tr>
<tr><td>1A</td><td>Base ply mechanically fastened at laps 6 in. o.c.; perimeter mechanically fastened at laps 6 in. o.c. with one additional row of fastening in the center; corner mechanically fastened at laps 6 in. o.c. with two additional rows of fastening. Insulation and cover board preliminarily fastened. Base ply is mechanically fastened; top cap ply adhered.</td><td>
</td></tr>
<tr><td>1B</td><td>Base ply mechanically fastened at laps 12 in. o.c.; perimeter mechanically fastened at laps 12 in. o.c. with one additional row of fastening in the center; corner mechanically fastened at laps 12 in. o.c. with two additional rows of fastening. Insulation and cover board preliminary fastened. Base ply is mechanically fastened; top cap ply adhered.</td><td>
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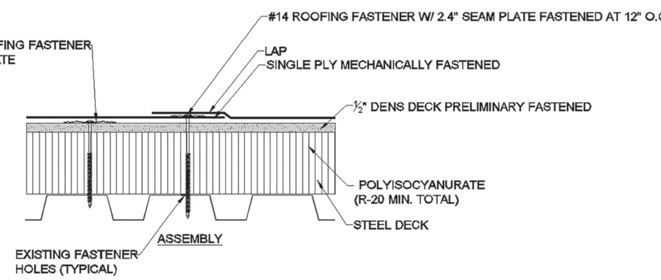
<tr><td>1C</td><td>Single-ply mechanically fastened at laps 12 in. o.c.; perimeter mechanically fastened at laps 12 in. o.c. with one additional row of fastening in the center; corner mechanically fastened at laps 12 in. o.c. with two additional rows of fastening. Insulation and cover board preliminary fastened.</td><td>
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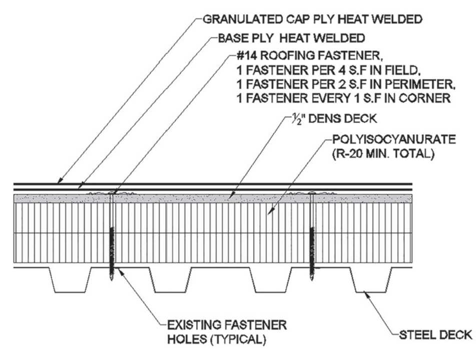
<tr><td>2</td><td>Field, one fastener every 4 sq. ft.; perimeter, one fastener every 2 sq. ft.; corner, one fastener every 1 sq. ft.</td><td>
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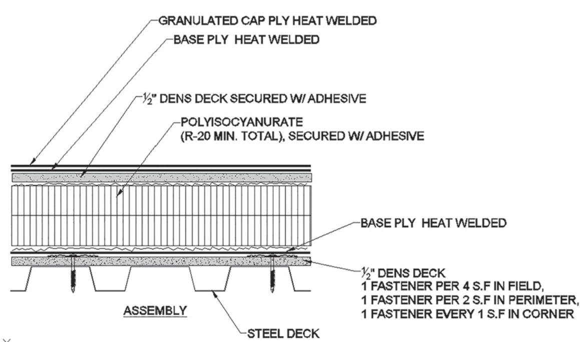
<tr><td>3</td><td>Field, one fastener every 4 sq. ft.; perimeter, one fastener every 2 sq. ft.; corner, one fastener every 1 sq. ft.</td><td>
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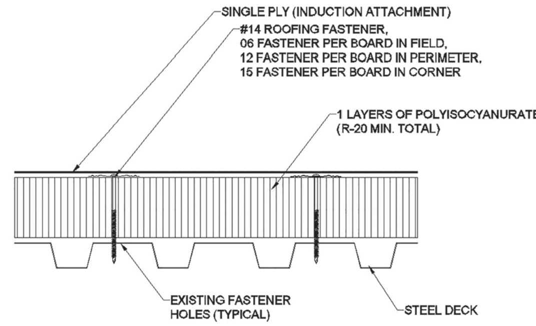
Table 1 – Reroofing assembly types, fastening patterns, and sections.

<table>
<tr><th>Type</th><th>Fastening Pattern</th><th>Section</th></tr>
<tr><td>4A</td><td>Field, 6 fasteners per board; perimeter, 10 fasteners per board; corner, 15 fasteners per board with single layer of polyisocyanurate insulation.</td><td>
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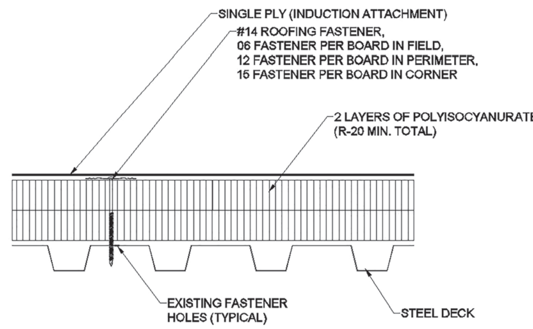
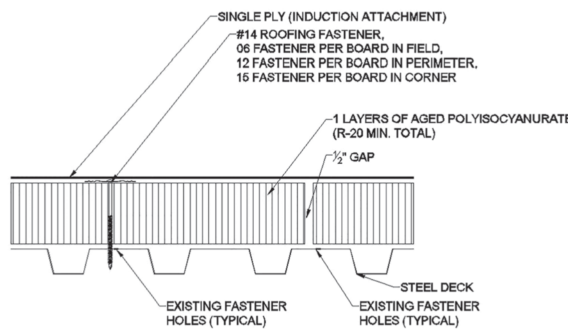
<tr><td>4B</td><td>Field, 6 fasteners per board; perimeter, 10 fasteners per board; corner, 15 fasteners per board with 2 layers of polyisocyanurate staggered.</td><td>
</td></tr>
<tr><td>4C</td><td>Field, 6 fasteners per board; perimeter, 10 fasteners per board; corner, 15 fasteners per board with single layer of polyisocyanurate and ½-in. gap between aged insulation.</td><td>
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Table 1 (continued) – Reroofing assembly types, fastening patterns, and sections.

Re-Cover Assembly Systems

In this system, the existing roof assembly receives mechanically fastened new roof assemblies. Within this general roof assembly system, we have identified two scenarios—namely existing lightweight insulating concrete (type 1) and existing rigid insulation (type 2). See *Appendix B* for a detailed description of thermal barrier/cover board, vapor/air barrier, insulation, cover board, and roof membrane. *Table 2* lists re-cover assembly types, fastening patterns, and sections.

3. HEAT TRANSFER PARAMETERS AND ASSUMPTIONS

Heat Transfer Properties of Roof Components

Table 2 lists the material thermal properties of roof components used in this study. The thermal properties were obtained from The *NRCA Manual* (2014), Appendix 3, "Typical Thermal Properties of Building Materials."

Assumptions

The structural slope in the deck is ¼ in. to 1 ft., with a low-slope roof with uniform thickness of insulation of R-20. The insulation requirement is based on ASHRAE

Material	Thickness (inches)	Thermal Properties (Btu/h•ft²•°F)
Polymer-Modified Bitumen	⅜	3
Single Ply	⅜	3
Gypsum Roof Board	½	1.79
Polyisocyanurate Insulation	3.5	0.0511
Lightweight Insulating Concrete	2	0.075
Metal Deck – Steel (Rolled, Ground)	0.029	19.25
Steel Fasteners – Galvanized Steel (0.14% C)	0.263	23.88

Table 2 – Material thermal properties.

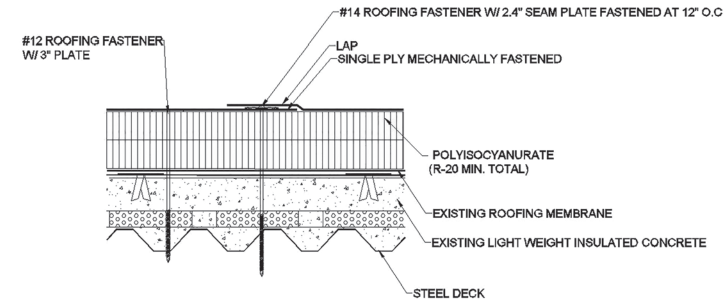
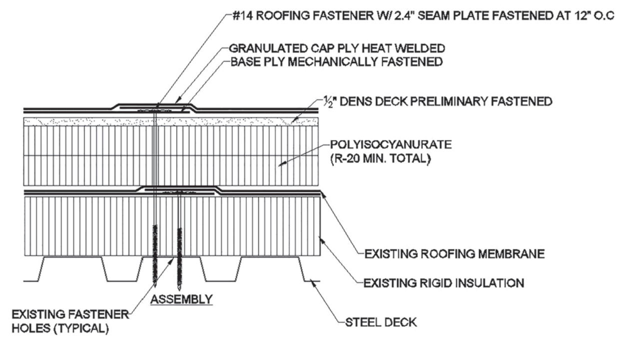
Type	Fastening Pattern	Section
1	Single-ply, mechanically fastened at laps 12 in. o.c.; perimeter mechanically fastened at laps 12 in. o.c. with one additional row of fastening in the center; corner mechanically fastened at laps 12 in. o.c. with two additional rows of fastening.	
2	Base ply mechanically fastened at laps 12 in. o.c.; perimeter mechanically fastened at laps 12 in. o.c. with one additional row of fastening in the center; corner mechanically fastened at laps 12 in. o.c. with two additional rows of fastening. Insulation and cover board preliminary fastened. Top cap ply adhered.	

Table 2 – Re-cover assembly types, fastening patterns, and sections.

Climatic Zones	Summer Design Temperature (°F)	Winter Design Temperature (°F)
CZ3 (Atlanta, GA)	93	18
CZ2 (Orlando, FL)	94	37
CZ6 (Saint Paul, MN)	91	-16

Table 3 – Outdoor design temperature.

90.1-2007. In this standard, the above-deck insulation for all climatic zones (tables 5.5.1 to 5.5.8) is R-20. For this study, the roof is assumed to have a metal edge flashing, and no parapet is included. For calculation purposes, the size of the roof is assumed to be 100 squares (i.e., 100 x 100 ft.). The height of the building is assumed to be less than 60 ft. Hence, per ASCE 7 and FM 1-28 datasheet, the corner zone is 10 x 10 ft., leaving the field and perimeter zones to be 6,400 sq. ft. and 3,200 sq. ft., respectively. It is to be noted that two roof assembly systems and their subtypes are studied with weather files representing three climatic zones (CZ)—namely CZ2 (Orlando, FL), CZ3 (Atlanta, GA), and CZ6 (Saint Paul, MN). These climatic zones are based on ASHRAE 90.1-2007. The outdoor design conditions used for this study are per requirements discussed in *The NRCA Manual*, Appendix 6, "Climatic Design Information." The inside surface conductance used for the analyses is 1.08 Btu/h•ft^2•°F (ASHRAE 2005). *Table 3* lists summer and winter design temperature for the three representative cities used in this study.

4. RESULTS AND OBSERVATIONS

In this section, we discuss the results of one reroofing (type 1A; see section 4.1) and roof recover (type 2; see section 4.2), with illustrations depicting the isotherms, flux vectors at the interface of fastener and

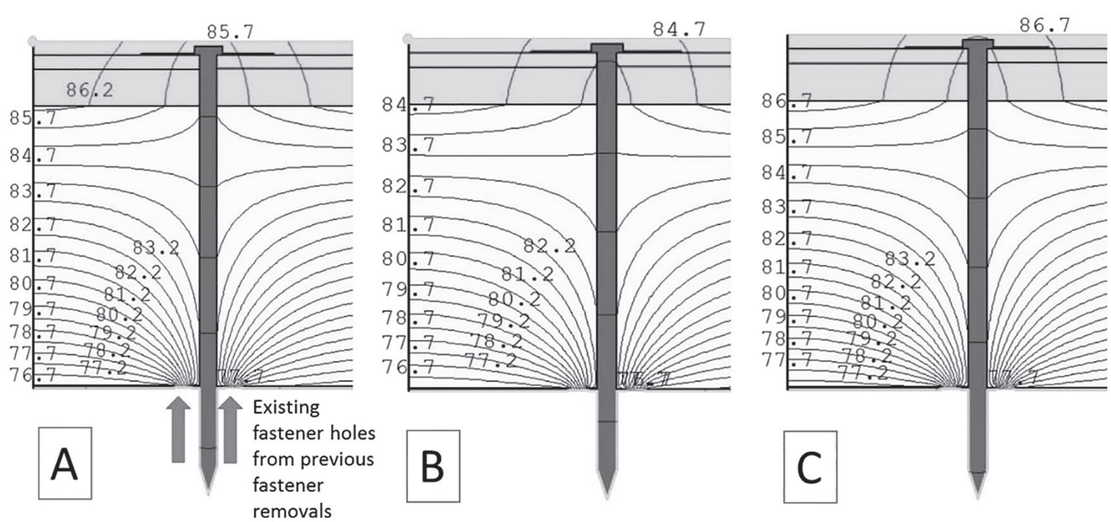


Figure 5 – Isotherms of reroofing type 1A for representative cities for field zone of the roof for (A) CZ3 (Atlanta, GA), (B) CZ2 (Orlando, FL), and (C) CZ6 (Saint Paul, MN).

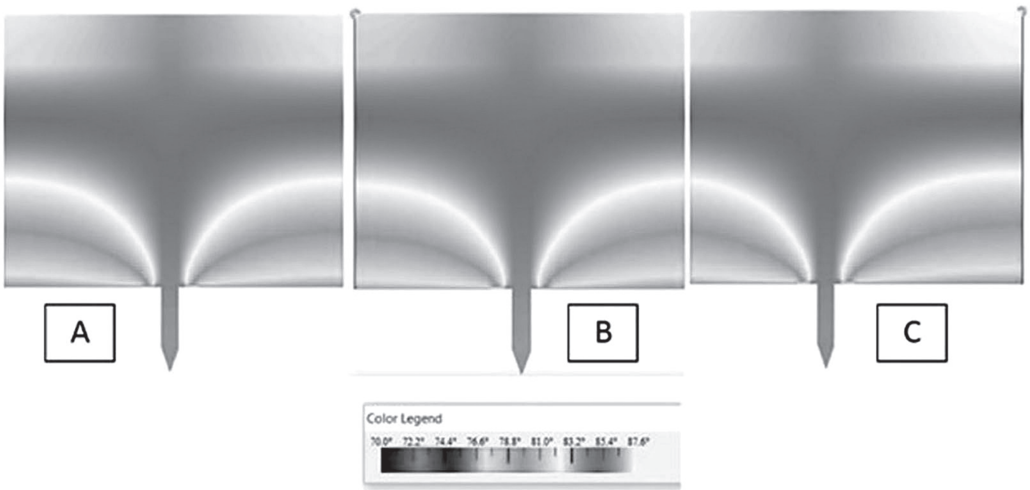


Figure 6 – Temperature profile of reroofing type 1A for representative cities for field zone of the roof for (A) CZ3 (Atlanta, GA), (B) CZ2 (Orlando, FL), and (C) CZ6 (Saint Paul, MN).

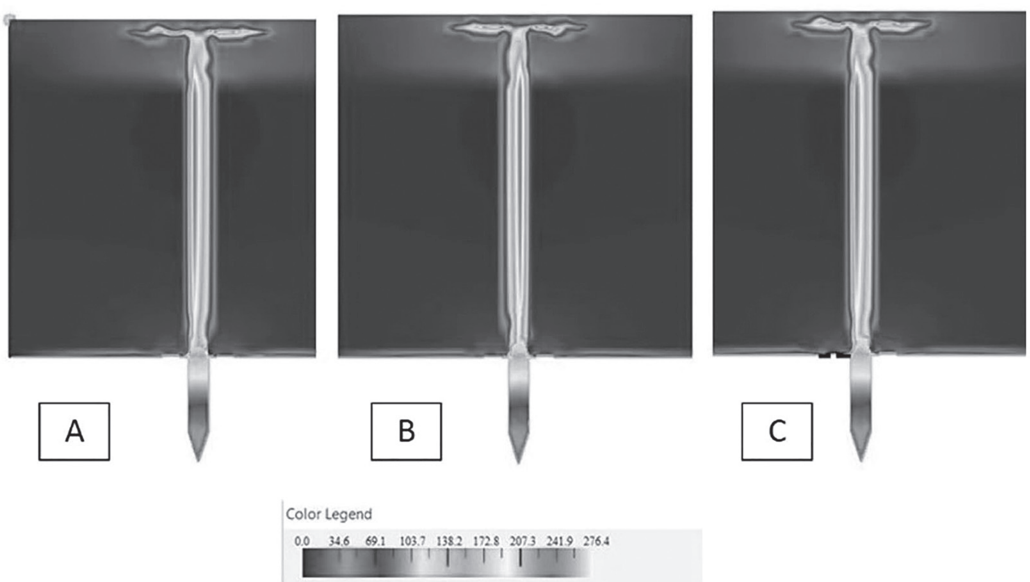


Figure 7 – Thermal break of reroofing type 1A for representative cities for field zone of the roof for (A) CZ3 (Atlanta, GA), (B) CZ2 (Orlando, FL), NS (C) CZ6 (Saint Paul, MN).

metal deck, temperature profile, and thermal break. We will also discuss the overall energy impacts of all reroofing and roof recover assembly systems.

Reroofing Type 1A Results

Figures 5 to *7* show the isotherms, flux vectors, temperature profiles, and thermal bridges studied for three climatic zones. The results shown in these figures relate to summer day conditions. The study of reroofing type 1A under summer day conditions shows downward heat flow for all climatic zones (CZ2, CZ3, and CZ6). It is evident that the presence of existing fastener holes (that were made by the previous fasteners) impact the flow of heat.

Roof Recover Type 2 Results

Figures 8A, *8B*, and *8C* show the isotherms. *Figures 9* and *10* show the temperature profiles and thermal bridges respectively studied for three climatic zones. The results shown in these figures relate to summer day conditions.

Energy Impacts of Metal Fasteners Reroofing and Roof Re-Cover During Summer and Winter

The energy impacts of metal fasteners are calculated as follows. The total heat released to the interior through the roof assembly is the summation of two components: 1) the heat transfer released from metal deck without fastener penetration, and 2) the heat transfer released from fasteners. The heat released (i.e., Q [units: Btu/h]) is the product of heat transfer coefficient (unit: [Btu/ft^2-h-°F), area metal deck and fasteners (unit: ft^2), and temperature difference (°F).

In order to do a comparative analysis of the roof performance, we analyzed the heat entering through the roof assemblies in different scenarios. This parameter is chosen as it not only determines the envelope performance, but also impacts the heating and cooling loads. The metal deck and the fastener temperatures were calculated using THERM, and we used the equations to compute the total heat entering through the assemblies.

Burch et al.'s 1986 paper on heat transfer in metal fasteners used a finite difference method (FDM). The FDM uses a topologically square network of lines to construct the discretization of the partial differential equation (PDE). This is a potential bottleneck of the method when handling complex geometries in multiple dimensions. THERM modeling employed in our models uses finite element analysis (FEA), which is advantageous in situations where complicated geometries are employed. FEA uses an integral form of PDE and helps in increasing accuracy of our analysis.

Figure 11 shows the heat gain during summer (bars shown along positive Y axis) and heat loss during winter (bars shown along negative Y axis) for various roof assemblies used in this study (i.e., reroofing options 1A, 1B, 1C, 3, and 4A; and re-cover option 2) for CZ3, CZ2, and CZ6. For CZ3 (Atlanta, GA), it can be observed that reroofing option 3 performs better than other reroofing options. Reroofing option 3 from metal deck above is mechanically fastened cover board, adhered membrane, adhered insulation, adhered cover board, and adhered roofing membrane.

Impact of metal fastener density

It can be observed that reroofing option 1A, which has more fastener density that reroofing option 1B, tends to show more heat loss. Moreover, it can also be expected that more heat loss may appear at roof corners and perimeters when compared to field zones; this is again due to increased fastener density (*Figure 11*).

Impact of single-ply (white-colored membrane) and modified bitumen

It can be observed that reroofing option 1B shows less heat loss during winter compared to option 1C, owing to lower heat retention of white roofs through reflectivity.

Impact of existing holes in the metal deck

For reroofing option 1C, the roof assembly above the metal deck is R-20 insulation, cover board, single ply, and mechanically fastened at laps. *Figure 12* shows an axonometric view of existing fastener holes next to fasteners in metal deck. Additional simulations were performed on reroofing option 1C, both with and without holes (*Figures 13* and *14* and *Table 4*).

Reroofing option 1C with holes has a fastener temperature of 83.9°F, whereas the same option without holes has a fastener temperature of 82.3°F, which causes higher

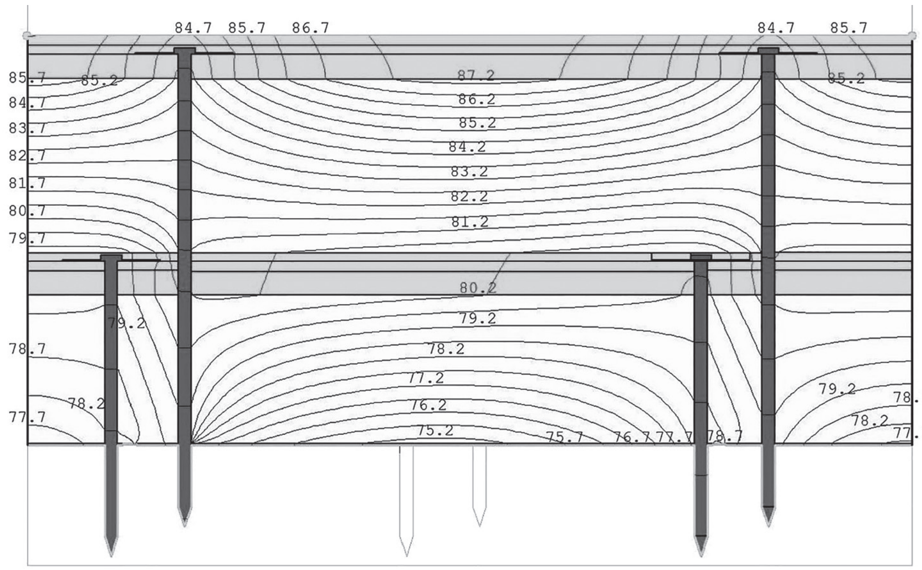


Figure 8A – Isotherms of reroofing type 2 for representative cities for field zone of the roof for (A) CZ3 (Atlanta, GA).

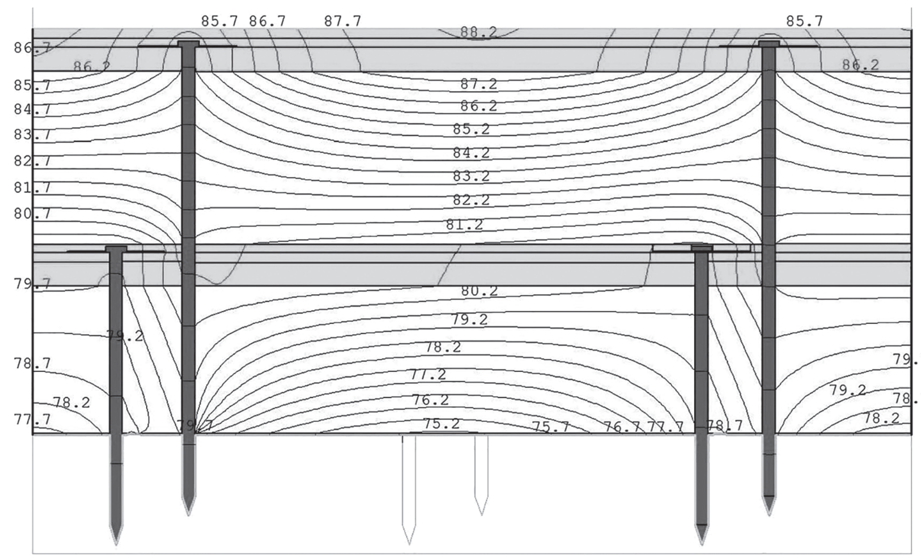


Figure 8B – Isotherms of reroofing type 2 for representative cities for field zone of the roof for (B) CZ2 (Orlando, FL).

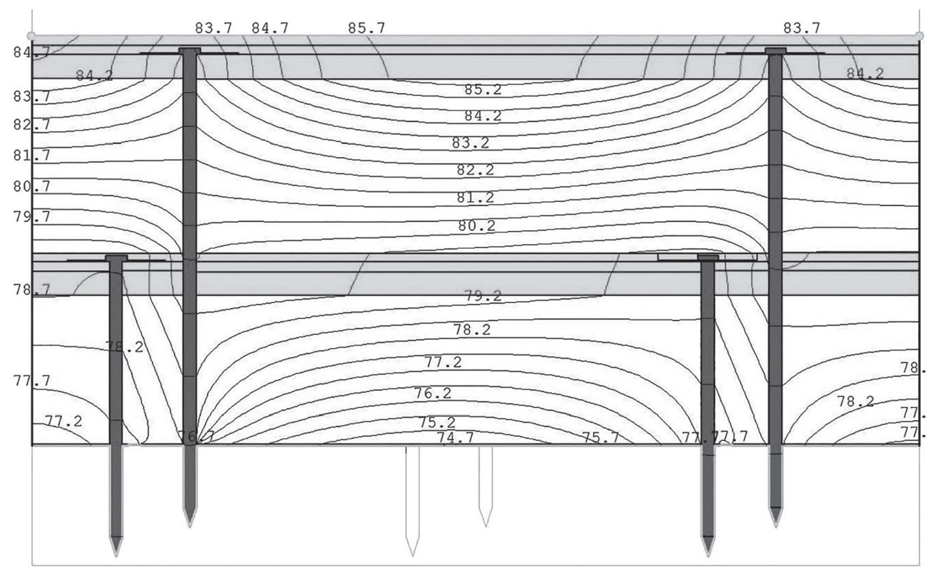


Figure 8C – Isotherms of reroofing type 2 for representative cities for field zone of the roof for (C) CZ6 (Saint Paul, MN).

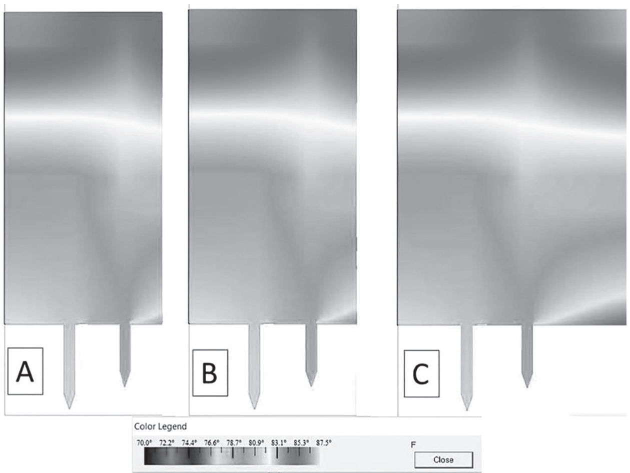


Figure 9 – Temperature profile of reroofing type 2 for representative cities for field zone of the roof for (A) CZ3 (Atlanta, GA), (B) CZ2 (Orlando, FL), and (C) CZ6 (Saint Paul, MN).

Figure 10 – Thermal break of reroofing type 2 for representative cities for field zone of the roof for (A) CZ3 (Atlanta, GA), (B) CZ2 (Orlando, FL), and (C) CZ6 (Saint Paul, MN).

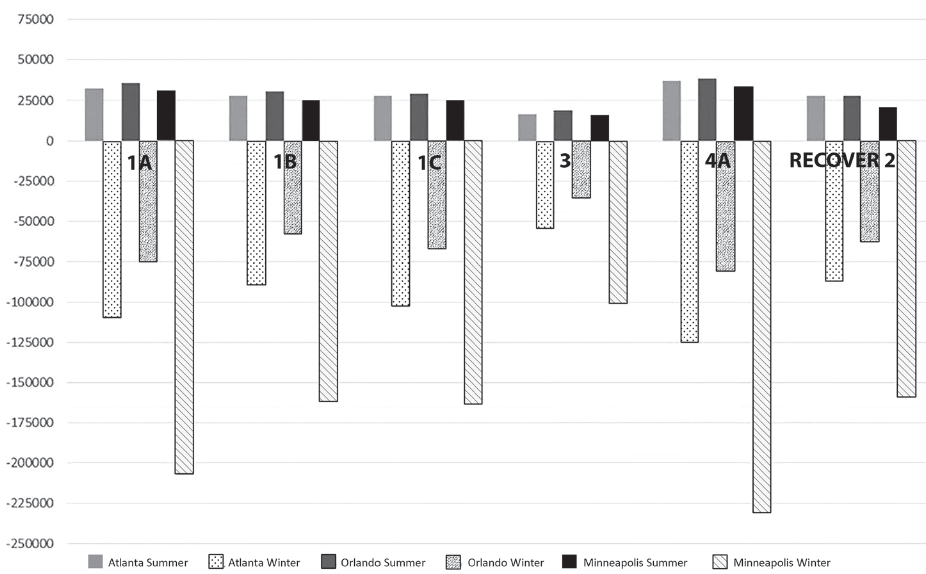


Figure 11. Energy loss (i.e., summer and winter) of reroofing and re-cover scenarios for CZ3 (Altanta, GA), CZ2 (Orlando, FL), and CZ6 (Saint Paul, MN).

thermal break through the roof with holes. Yet, as the fastener area is significantly smaller than the metal deck area, this phenomenon does not cause the overall roof thermal performance to drop. As illustrated in simulation results (*Figures 13* and *14*), the presence of existing fastener holes causes temperature isotherms' curve towards conducting metal fasteners. This results in concentration of heat energy at fasteners and higher temperature as heat exits out of the fastener tip more quickly than the adjacent surface. In other words, the main reason for the observed thermal break is that the metal fasteners cause the isotherms to curve towards the fasteners (i.e., the thermal gradient is higher as it approaches a fastener); thus, the increased temperature at the fasteners' exits and an overall increase in temperature.

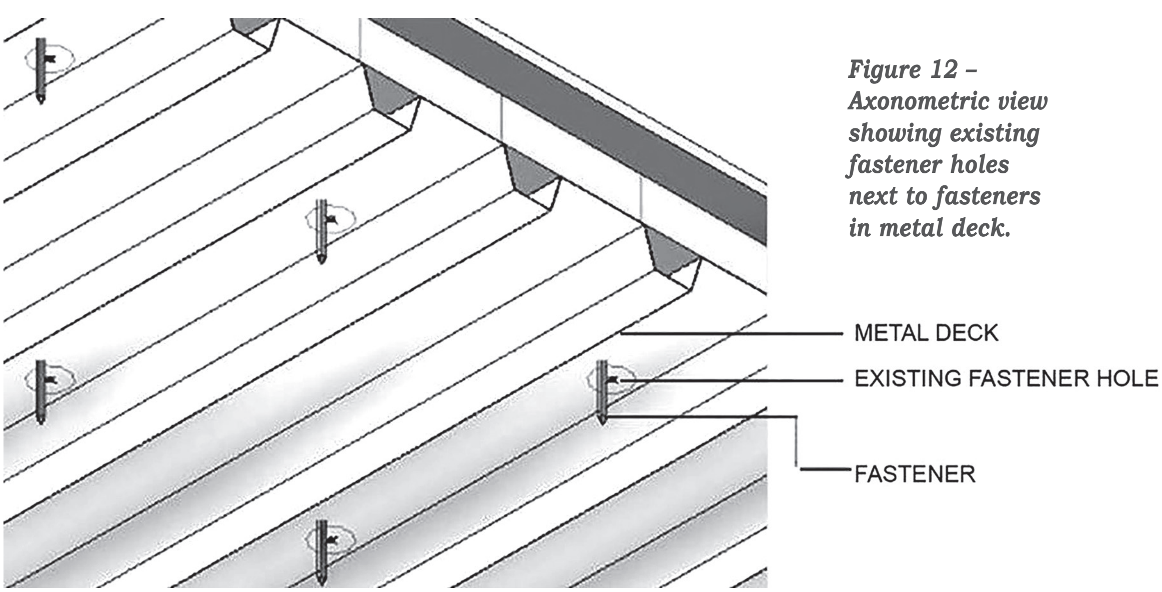


Figure 12 – Axonometric view showing existing fastener holes next to fasteners in metal deck.

5. CONCLUSIONS AND FUTURE WORK

In this paper, the energy impacts of roof fasteners for the most commonly used metal deck roofing system configuration under various scenarios, including reroofing and roof re-cover (addition of new low-slope roof membrane over existing roofs) were quantified. Overall, nine roof assembly systems were studied using THERM for three climatic zones: i.e., CZ2 (Orlando, FL), CZ3 (Atlanta, GA), and CZ6 (St. Paul, MN). Energy impact for reroofing options 4B and 4C, and recover option 1 will be analyzed for future work. For consistency purposes, all roof assembly systems used R-20 insulation per ASHRAE 90.1-2007 requirements. The impact of existing fastener holes was discussed in this paper.

Future study will focus on overall thermal loss, as a percentage, in metal deck roof assembly systems owing to metal fasteners for reroofing and roof recover scenarios. The objective of such a study is to aid standards organizations such as ASHRAE in determining minimum insulation requirements for commercial roof assembly systems. The current study does not evaluate the impact of moisture penetration.

In both reroofing and roof re-cover scenarios, holes and existing fasteners left out may enhance moisture penetration. Moisture penetration may also happen at deck and side laps. This may be studied using a software tool that takes into consideration moisture penetration, as well. Future study will bridge this gap using state-of-the-art simulation technologies. It is to be noted that this study employed THERM software to analyze the impact of metal fasteners. The climate conditions input in the software are limited and may not represent the actual weather conditions. One approach is to develop field-testing wherein thermocouples are built into roof assembly systems for short- and long-term monitoring purposes. Performance analyses in extreme climates are vital for calibrating software simulations for strengthening standards development.

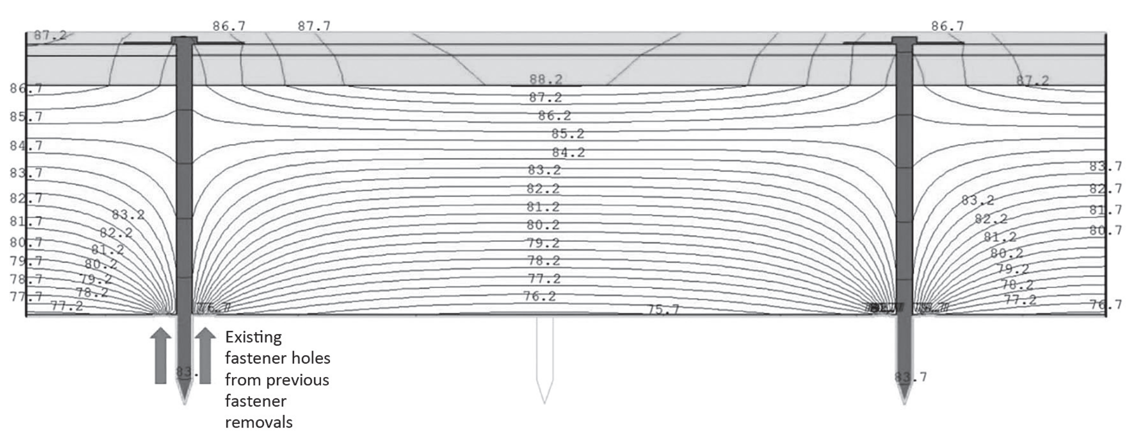


Figure 13 – Temperature isotherms of reroofing option 1C with fastener holes.

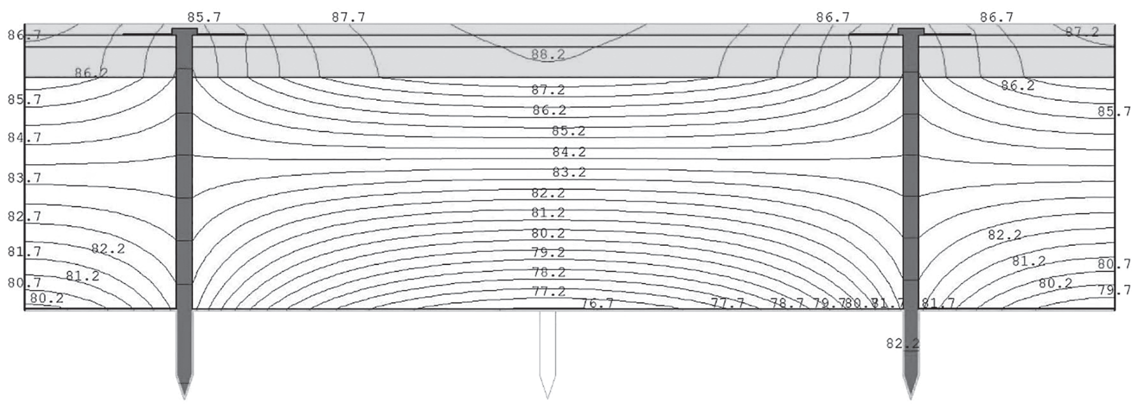


Figure 14 – Temperature isotherms of reroofing option 1C without fastener holes.

Reroofing Option 1C	Metal Deck Temperature (ºF) Adjacent to Tip	Fastener Temperature (ºF) at tip
With fastener holes	76.2	83.9
Without fastener holes	78.2	82.3

Table 4 – Metal deck and fastener temperatures of reroofing option 1C with and without fastener holes.

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APPENDIX A

Reroofing: Roof assembly description from structural deck above

Re-cover / Reroofing		Reroofing							
Roof Assembly		Type 1A	Type 1B	Type 1C	Type 2	Type 3	Type 4a	Type 4b	Type 4c
Reference		FM Data Sheet 1-29, 2.2.7.2, Manufacturer fastening pattern	FM Data Sheet 1-29, 2.2.7.2, Manufacturer fastening pattern	FM Data Sheet 1-29, 2.2.7.2, Manufacturer fastening pattern	FM Data Sheet 1-29, 2.2.7.2	FM Data Sheet1-29, 2.2.1.5, Adhesive ribbon spacing per manufacturer	Manufacturer sheet	Manufacturer sheet	Manufacturer sheet
Thermal Barrier / Cover board	Material	None	None	None	None	Gypsum	None	None	None
	Attachment	None	None	None	None	Mechanical	None	None	None
Vapor / Air Barrier	Material	None	None	None	None		None	None	None
	Attachment	None	None	None	None		None	None	None
Insulation	Material	R-20 Polyiso (single layer)	R-20 Polyiso (single layer)	R-20 Polyiso (single layer)	R20 Polyiso (single layer)	R-20 Polyiso (single layer)	R-20 Polyiso (single layer)	R-20 Polyiso (single layer)	R-20 Polyiso (single layer)
	Attachment	Mechanical	Mechanical	Mechanical	Mechanical	Adhered	Mechanical	Mechanical	Mechanical
Cover board	Material	Gypsum Roof Board	Gypsum Roof Board	Gypsum Roof Board	Gypsum Roof Board	Gypsum Roof Board	None	None	None
	Attachment	Mechanical	Mechanical	Mechanical	Mechanical	Adhered	None	None	None
Roof Membrane	Material	Modified Bitumen (1)	Modified Bitumen (2)	Modified Bitumen (2)	Modified Bitumen	Modified Bitumen	Single ply	Single ply	Single ply
	Attachment	Mechanical	Mechanical	Mechanical	Adhered	Adhered	Induction	Induction	Induction

APPENDIX B

Recover: Roof assembly description from structural deck above

	Re-cover / Reroofing		Recover	
	Roof Assembly		Type 1	Type 2
	Reference		FM Data Sheet 1-29, 2.2.7.2, Manufacturer fastening pattern	FM Data Sheet 1-29, 2.2.7.2, Manufacturer fastening pattern
Existing	Insulation	Material	Lightweight insulating concrete	Rigid insulation
		Attachment	None	Mechanical
	Cover Board	Material	None	None
		Attachment	None	None
	Roof Membrane	Material	Modified Bitumen	Modified Bitumen
		Attachment	Mechanical in to lightweight only	Mechanical
Re-cover	Barrier Board	Material	None	None
		Attachment	Mechanical	None
	Insulation	Material	R20 Polyisocyanurate (single layer)	R20 Polyisocyanurate (single layer)
		Attachment	Mechanical	Mechanical
	Cover Board	Material	None	Gypsum Roof Board
		Attachment	None	Mechanical
	Roof Membrane	Material	Single ply	Modified Bitumen
		Attachment	Mechanical	Mechanical