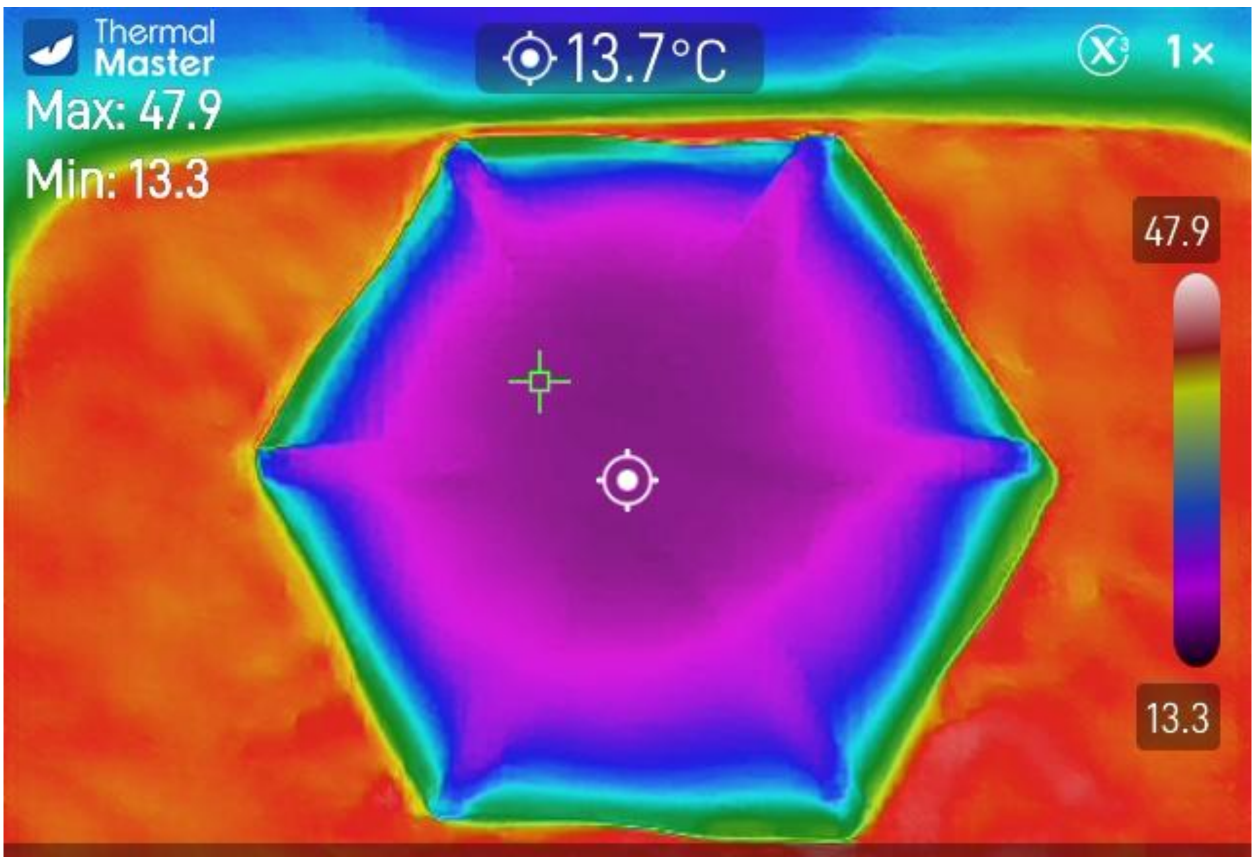
TERRY FRANK
CONSULTING INC.

Estimation of Thermal Properties of all Hexa-Cover® Models



Thermal image of Hexa-Cover Model API floating in 48° C hot water

February 2026 Rev.0

Thermal Performance Evaluation of Modern Hexa-Cover Designs Compared to [1]Aalborg University Study for the Legacy Model R114

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Executive Summary

This study extends the Aalborg University thermal performance analysis of the legacy Hexa-Cover R114 model to three modern designs: **ED**, **HD**, and **API**. Using a modernized EPS foam test module and the same three-experiment energy-balance method employed in the Aalborg study, the thermal resistance (R-value) and heat-transfer coefficient (U-value) of each model were quantified under controlled cooling conditions.

All three new models demonstrated substantial insulation improvements relative to a free water surface and significantly outperformed the R114 design. After correcting for background heat loss through the EPS module, the API, HD and ED models stabilized at R-values near **0.31 m²·K/W**, compared to **0.13 m²·K/W** for the R114. This represents a **2.38 times improvement in thermal resistance**. Operationally, the new models reduced conducive, convective, and radiant heat flux by **up to 87.7%** relative to open water, compared to **74%** for the R114 model.

Although this study was designed to minimize evaporative losses so that the conductive, radiant, and convective heat transfer could be isolated, independent testing has shown that Hexa-Cover systems also reduce evaporative losses by **65–77%** depending on the liquid type and environmental conditions. In open basins, evaporative and convective heat losses can dominate the total heat-loss profile. When a floating cover is installed, evaporative losses are suppressed, shifting the energy-balance emphasis toward conductive and radiant heat transfer – the components quantified in this study. These findings support the use of ED, HD, and API models in industrial and municipal basins where thermal retention, energy savings, and hydrocarbon compatibility are critical.

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1. Introduction

Hexa-Cover® floating insulation systems are widely used to reduce evaporation, odors, volatile organic compounds, toxic emissions, and heat loss from water, wastewater and industrial process basins. The original *Thermal Properties Study* established a benchmark (R-value) of **0.13 m²·K/W** for the polypropylene R114 model. While the R114 design has proven effective for routine water, wastewater, and agricultural applications, more demanding industrial environments require enhanced chemical compatibility, improved durability, and greater thermal performance.

To address these needs, Hexa-Cover A/S has developed three modern patented designs:

- **ED** (Extreme Duty, nylon)
- **HD** (Heavy Duty, nylon)
- **API** (**A**dvanced **P**erformance **I**nsulation, polypropylene)

These models incorporate updated geometries, optimized material properties, and lower densities to improve float performance, hydrocarbon compatibility, and thermal insulation.

The objective of this study is to quantify the thermal insulation performance of the ED, HD, and API models using a methodology directly comparable to the Aalborg University R114 study. The analysis focuses on conducive, radiative, and convective heat transfer under controlled cooling conditions. Heat-flux reduction relative to open water is used as the primary performance metric, enabling direct comparison to the legacy R114 results.

A modernized EPS foam test module was constructed to replicate the Aalborg experimental configuration, with the enhancement of designing the geometry such that there would be a 4-inch material thickness in every direction such that heat loss could be more uniform. The module was instrumented with temperature sensors and sealed to minimize external heat and evaporative losses. Three Hexa-Cover models (ED,HD,API) were evaluated alongside an open-water control and compared to the R114 benchmark. This study provides a rigorous, repeatable, and directly comparable assessment of modern Hexa-Cover designs, demonstrating their suitability for industrial and municipal applications where thermal retention and energy efficiency are critical.

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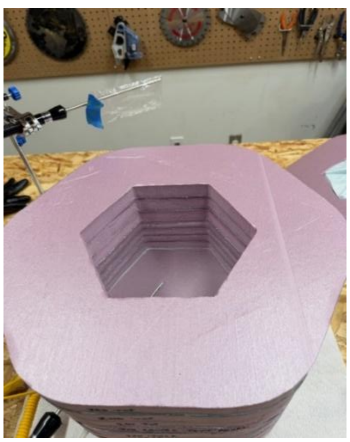
2. Methods

2.1 Experimental Setup

A modernized EPS foam test module was constructed to replicate the thermal-performance evaluation conditions used in the Aalborg University R114 study. The module was equipped with calibrated temperature sensors and sealed to minimize external heat and evaporative losses. Three Hexa-Cover models **ED, HD, API** were evaluated alongside an open-water control and compared to the legacy R114 benchmark.

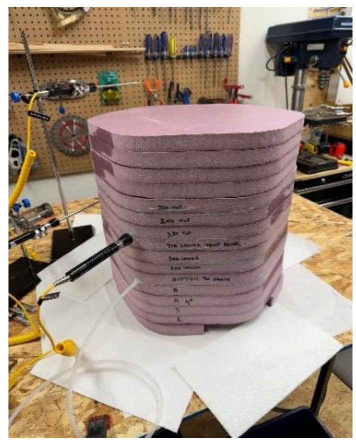
- Total module opening area with foam lid installed: 0.1878 m²
- Module opening area excluding the lid (used for background-loss correction): 0.1583 m²

These areas were used for all UA and U-value normalizations. Open-water results differed slightly from Aalborg's values due to ambient temperature and humidity variations, but these differences do not affect the comparative findings.



Empty Module Setup

Open Water Cycle



Foam Only Cycle

2.2 Experimental Procedure

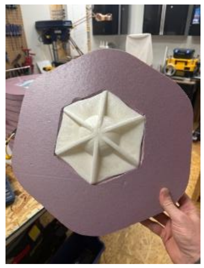
The Aalborg Study used three experiments to isolate the thermal resistance of the R114 plate:

1. **Experiment 1 — Open Water (Reference Condition)** The reservoir is filled with hot water and left uncovered. Heat escapes through the free water surface and through the EPS walls and floor, establishing the maximum heat-loss condition. Water temperatures were kept low enough to avoid evaporative mass loss influences the results.

2. **Experiment 2 — Foam-Only (Background Losses**) A 4-inch EPS lid is placed over the reservoir opening. Heat now escapes only through the EPS walls, floor, and lid. This experiment quantifies the background heat loss of the entire module. The foam-lid contribution was later removed to isolate the background losses associated with the module opening alone. This is also where various test covers are mounted.

3. **Experiment 3 — Hexa-Cover Installed**
   Each Hexa-Cover model (ED, HD, API) are placed in the module opening using a removable carrier plate. Heat escapes through the EPS module and through the installed Hexa-Cover. Subtracting the background losses measured in Experiment 2 isolates the cover-only heat transfer coefficient.


API Carrier


HD Carrier


ED Carrier On Test Module


Hexa-Cover R114

Each test involved filling the EPS foam module with heated water and allowed it to cool naturally. Temperature data were recorded at regular intervals over **26-to-116** hours, depending upon the experiment. Open-water cycles used **30-second** sampling intervals, while longer cycles utilized **120-second** intervals.

2.3 Data Analysis

Cooling curves were generated from the recorded temperature data. Finite-difference slopes ($\Delta T/\Delta t$) were calculated to estimate heat transfer coefficients (U-values). Background heat losses were subtracted to isolate the thermal resistance of each cover.

The key formulas used to isolate the thermal parameters are as follows:

2.4 Energy-Balance Framework

The cooling of the water volume is governed by the standard energy-balance equation:

$$U = \frac{\Delta T\_water \cdot C\_water \cdot V \cdot \rho\_water}{A \cdot \Delta t \cdot (T\_water - T\_air)}$$

Where:

U = heat-transfer coefficient ($W/m^2 \cdot K$)
R = thermal resistance = 1 / U ($m^2 \cdot K/W$)
T_water = water temperature (°C)
T_air = ambient temperature (°C)
C_water = specific heat capacity of water (J/kg·K)
V = water volume (m^3)
ρ_water = density of water (kg/m^3)
A = exposed surface area (m^2)
Δt = time step (s)

ΔT_water = change in water temperature over Δt

The cooling rate is computed using the finite-difference approximation:

$$\frac{\Delta T\_water}{\Delta t} \approx \frac{\partial T}{\partial t}$$

(This is identical to the Aalborg method).

2.5 Correcting for Background Heat Loss

The total heat leaving the system is the sum of heat escaping through the EPS module and through the Hexa-Cover test plate:

$$Q = U\_foam \cdot A\_foam \cdot (T\_water - T\_air) + U\_cover \cdot A\_cover \cdot (T\_water - T\_air)$$

Rearranging to isolate the cover-only U-value:

$$U\_cover = \frac{\Delta T\_water \cdot C\_water \cdot V \cdot \rho\_water - U\_foam \cdot A\_foam \cdot (T\_water - T\_air)}{A\_cover \cdot (T\_water - T\_air)}$$

2.6 Cover R-Value

The thermal resistance of the cover is:

$$R\_cover = \frac{1}{U\_cover}$$

This expression removes all background losses and yields the true R-value of the cover plate, directly comparable to Aalborg's R114 value of **0.13 m²·K/W.**

2.7 Quality Control

All experiments were repeated to ensure reproducibility. Data were checked for consistency, stability and outliers. The methodology closely followed the Aalborg University protocol to ensure direct comparability. Regression tables and R^2 values are provided in Appendix A.

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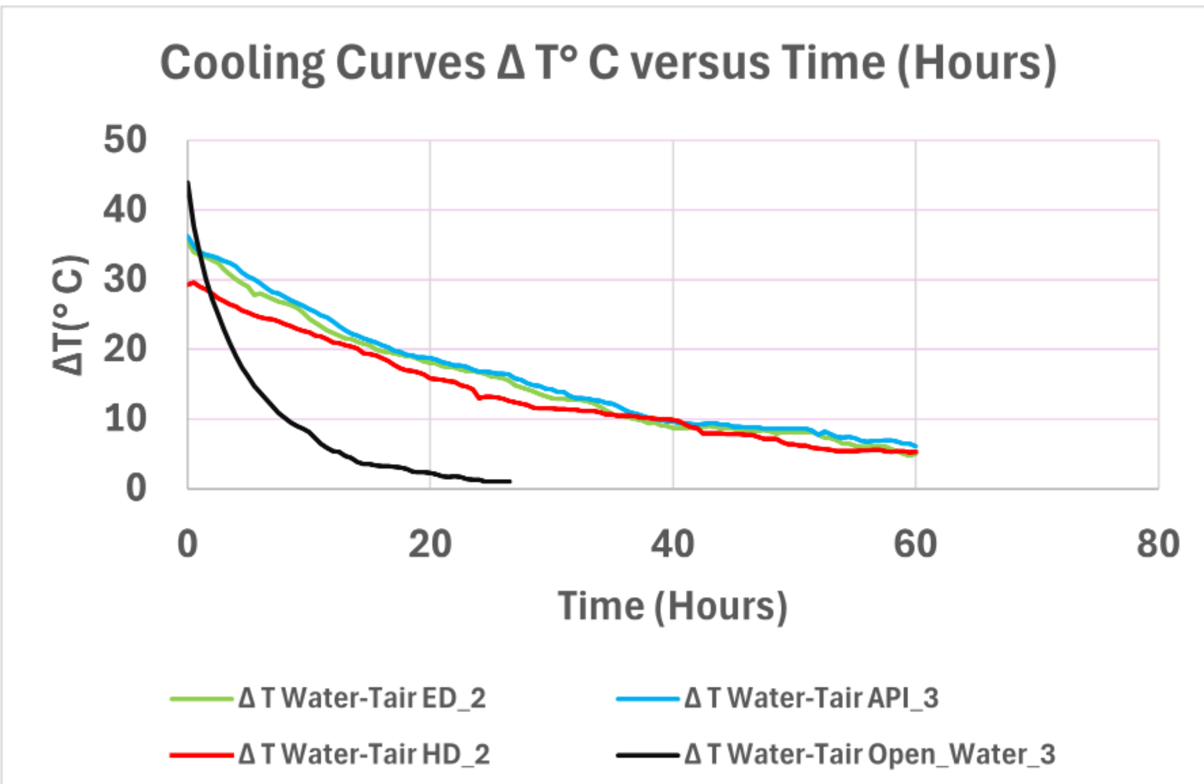
3. Results

3.1 Cooling Behavior

All experiments produced smooth, monotonic cooling curves suitable for slope-based U-value estimation. As expected, the **Open Water** condition cooled the fastest, followed by **ED**, **HD**, and **API**, with the **API model exhibiting the slowest cooling rate** (best insulation performance).

The R114 cooling curve from the Aalborg University study was not included in the plotted results because only final U and R values were available, not the raw temperature-time data. Multiple tests were performed to ensure stability and repeatability. Early runs were shortened due to module issues; once resolved, all runs were extended to a minimum of **60 hours**, with the foam-only background test running **116 hours**.

Figure 1. Cooling Curves for All Conditions



3.2 Heat-Transfer Characteristics

Finite-difference slopes ($\Delta T/\Delta t$) were computed for each time step to generate heat-flux curves. These curves illustrate the relationship between instantaneous temperature difference and heat-loss rate. The R114 values from the Aalborg study were added for comparison. The API model consistently demonstrated the lowest heat flux for a given ΔT, followed by ED and HD, with Open Water showing the expected highest heat flux.

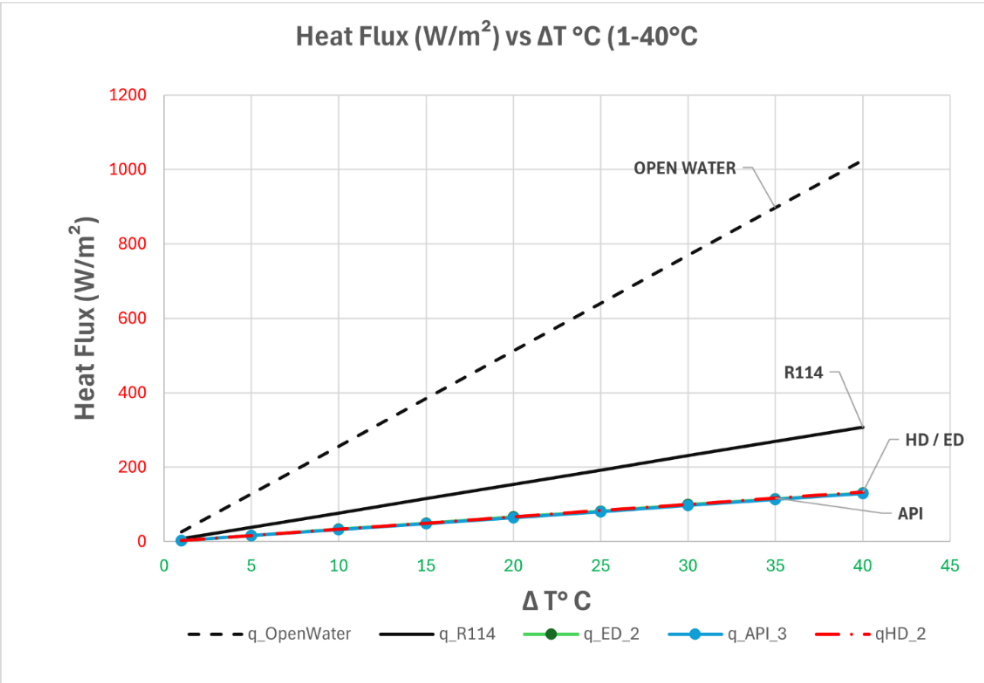


Figure 2. Heat Transfer Characteristic Curve.

3.3 U-Value / R- Value Stabilization

After subtracting background losses, using the foam-only experiment, the ED, HD, and API models converged to stable U-values. These values were normalized using the exposed module area **(0.1583 m²)** to allow direct comparison across all models. Aalborg's Open Water U-value (28.6 W/m²·K**)** differed slightly from the value measured in this study (25.54 W/m²·K), likely due to ambient conditions.

Normalized U-Values and R-Values

Open Water	25.54	Open Water	0.0392
• ED	3.1969	• ED	0.3128
• HD	3.2599	• HD	0.3068
• API	3.1361	• API	0.3189
• R114	7.70	• R114	0.1299

Final U-Value (W/m²·K) **R-Value (1/U) m²·K/W Comparison**

These results show:

- All three modern models outperformed R114 by a factor of **~2.38×.**
- API provides the best insulation (lowest U, highest R).
- ED and HD perform nearly identically, with ED slightly better.
- Open Water remains the baseline for maximum heat loss.

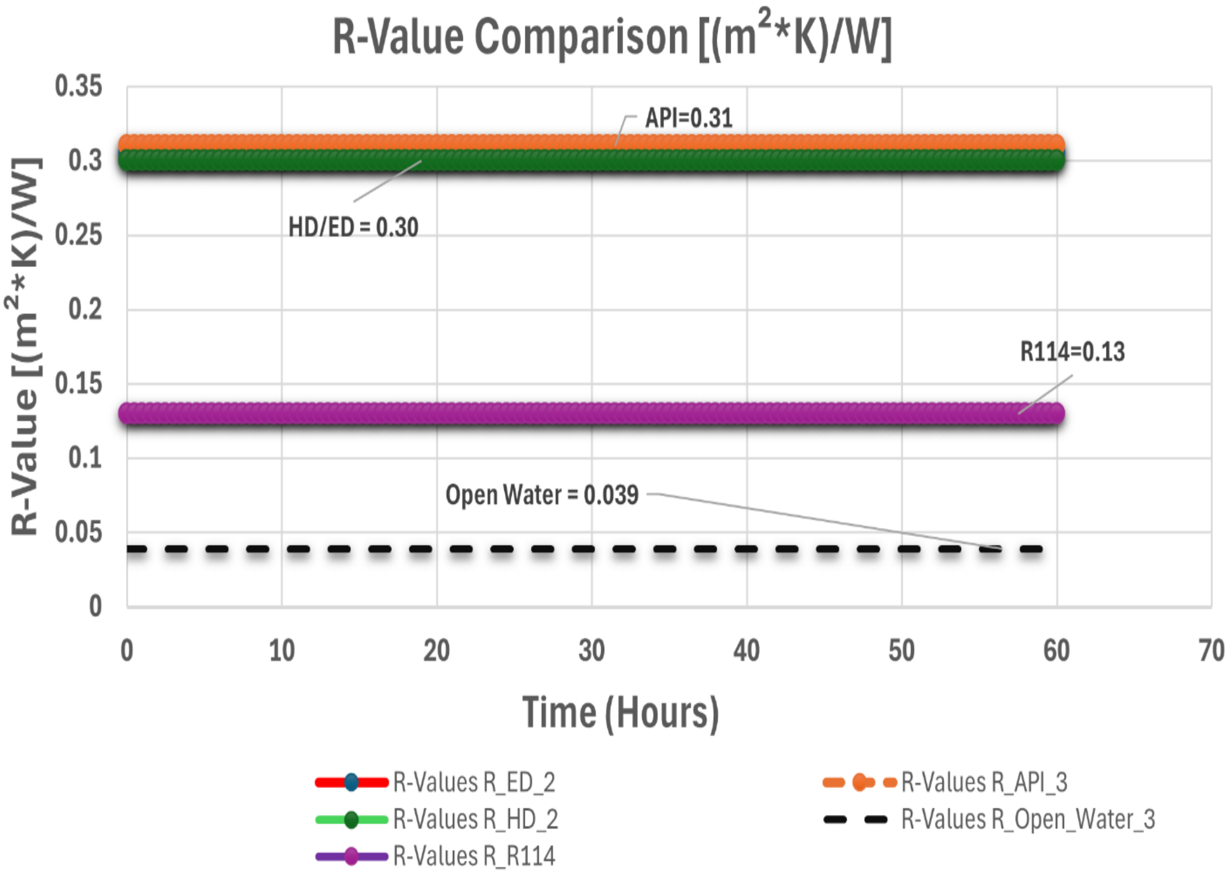


Figure 3. R-Value Comparisons

3.4 Summary of Key Findings

- **API** exhibited the highest thermal resistance **(R≈0.319 m²·K/W)**
- **ED** and **HD** followed closely **(R≈0.307- 0.313 m²·K/W)**
- All three models reduced heat flux by **87.2-87.7%** relative to open water.
- The legacy R114 model provided only 74% heat-flux reduction.
- Background losses were successfully isolated using the foam-only experiment.
- All results were stable, repeatable, and consistent with the Aalborg methodology.

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4. Discussion

4.1 Thermal Insulation Performance Interpretation

The thermal resistance values obtained for the ED, HD, and API models demonstrate a significant improvement over the legacy R114 design. The stabilized R-values for all new models near **0.31 m²·K/W** represent approximately a **2.38-fold increase** in insulation performance, relative to the benchmark value of **0.13 m²·K/W**. This improvement is consistent with the observed **87.2-87.7% reduction in heat flux** relative to open water. The API model provided the best overall performance, followed closely by ED and HD, which performed nearly identically. These results confirm that the updated geometries and materials used in the modern designs significantly reduce conductive, radiative and convective heat transfer.

4.2 Comparison to Aalborg R114

The methodology used in this study closely follows the Aalborg University protocol, enabling direct comparison to the R114 results. The R114 model's baseline R-value of **0.13 m²·K/W** and heat-flux reduction of **74%** relative to open water aligns with the values reported by Aalborg, validating both the experimental setup and the analytical approach used in this study. Although the Open Water U-value measured here **(25.54 W/m²·K)** differs slightly from the Aalborg's reported value **(28.6 W/m²·K**), this variation is expected due to differences in ambient temperature, humidity, and test module construction. These differences do not affect the comparative conclusions.

4.3 Material and Design Contributions

The enhanced performance of the ED, HD and API models is attributed to several design and material improvements:

- **Optimized geometry** reduces conductive pathways and increases thermal resistance.
- **Nylon and polypropylene materials** provide improved thermal characteristics and chemical compatibility.
- **Microcellular internal structures** reduce density and limit heat transfer through the cover.
- **Improved float performance** ensures consistent waterline immersion, stabilizing thermal behavior.

These design enhancements collectively contribute to the superior insulation performance observed in all three models.

4.4 Practical Implications

The substantial reduction in conductive, convective and radiative heat loss demonstrated by the ED, HD, and API models has significant implications for industrial and municipal applications:

- **Energy savings**: Reduced heat loss lowers heating requirements for process fluids, wastewater basins, and storage tanks.

- **Operational stability**: Improved thermal retention supports biological activity in cold-weather wastewater treatment.
- **Chemical compatibility**: Nylon-based ED and HD models expand applicability to hydrocarbon and chemically aggressive environments.
- **Emission reduction**: Lower heat loss reduces evaporative emissions, complementing independent findings showing **65-77% reductions** in evaporative losses.

These benefits make modern Hexa-Cover systems well-suited for energy-intensive facilities seeking improved efficiency and reduced environmental impact.

4.5 Limitations and Future Work

This study focuses on conductive, radiative, and convective heat loss under controlled laboratory conditions. While evaporative losses were intentionally minimized to isolate these components, real-world basins experience varying degrees of evaporative and convective heat transfer depending upon wind, humidity, and solar loading.

Future research should include:

- **Field scale validation** under varying environmental conditions
- **Combined thermal and evaporative-loss modelling** for full energy balance assessment
- **Long-term durability studies** for nylon and polypropylene models in aggressive chemical environments.
- **Large scale basin testing** to quantify performance under operational wind and weather conditions.

Independent laboratory testing (e.g., Exova's study on vapor sealing in heated toluene) and client reported field data already support the evaporative-loss reduction capabilities of Hexa-Cover systems. Integrating these findings with the thermal results presented here will provide a comprehensive understanding of total energy-savings potential. That type of analysis can be easily incorporated into an engineering spreadsheet for clients to analyze ROI etc.

4.6 Summary

The Hexa-Cover ED, HD and API models provide robust thermal insulation improvements, validated against a recognized and previously proven earlier model benchmark. Their enhanced performance, combined with improved material durability and chemical compatibility, makes them highly effective for managing heat loss in industrial and municipal basins. These results confirm that modern Hexa-Cover designs offer significant operational and energy-efficiency advantages over the legacy R114 model.

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5. Conclusions

The ED, HD, and API Hexa-Cover models provide significant thermal insulation benefits, outperforming the legacy R114 design by a factor of approximately **2.38**. Using a methodology directly aligned with the Aalborg University R114 study, the new models exhibit stabilized R-values near **0.31 m²·K/W** compared to **0.13 m²·K/W** for the R114.

After correcting for background heat loss through the EPS module, all three modern designs reduced conductive, convective, and radiant heat flux by **87.2-87.7 %** relative to open water. These results confirm that the updated geometries, materials, and microcellular structures of the ED, HD and API models provide substantial improvements in thermal performance.

When combined with independent laboratory evidence showing **65–77% reductions in evaporative losses**, Hexa-Cover systems offer a comprehensive solution for reducing total basin heat loss, improving energy efficiency, and minimizing emissions. This dual benefit- reduced evaporative and conductive heat loss – positions Hexa-Cover technology as a highly effective thermal-management strategy for industrial and municipal facilities.

ROI calculations based on the established R values clearly indicate that **capital investment** in Hexa-Cover systems **can be recovered within months**, even for basins with modest temperature differentials **(e.g., ΔT of 5°C).** Reduced heat loss also lowers energy-related carbon emissions, which may provide additional financial incentives in jurisdictions with carbon-pricing or emission-reduction programs.

Overall, the ED, HD and API models deliver robust, repeatable, and verifiable thermal-insulation performance that exceeds the capabilities of the legacy R114 design and meets the needs of modern industrial and municipal applications.

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6. Recommendations & Practical Applications

Hexa-Cover® systems provide substantial thermal-insulation benefits, chemical compatibility, and operational advantages across a wide range of industrial and municipal applications. Based on the measured U-and R-values, the following recommendations outline where each model delivers the greatest value.

6.1 Industrial Markets

Hexa-Cover systems are well-suited for industrial environments where thermal retention, emissions reduction, and chemical resistance are critical. Recommended applications include:

- **Petroleum and petrochemical tanks**
  Suitable for heated hydrocarbons, condensates and refinery intermediates.
- **Fracking fluids and produced water**

Reduces heat loss and suppresses volatile emissions during storage and treatment.

- **Refinery wastewater basins**
  Supports thermal stability and reduces odor and VOC emissions.
- **Chemical treatment ponds**
  Nylon-based ED and HD models provide enhanced compatibility with aggressive chemicals.
- **Mining and tailings ponds**
  Reduces evaporative losses and mitigates heat loss in cold-weather operations

6.2 Municipal Markets

Municipal water and wastewater facilities benefit from improved thermal retention, reduced chemical consumption, and enhanced process stability. Recommended applications include:

- **Drinking-water reservoirs**
  Reduces evaporative loss of treated or raw water and stabilizes disinfectant chemicals.
- **Wastewater treatment plants**
  Supports biological activity during cold-weather operation by reduced heat loss.
- **Stormwater retention ponds**
  Minimizes evaporative loss and supresses odors and surface emissions

6.3 General Recommendations

- **Use R114 or API** where thermal retention and low capital cost and quick ROI is a priority. API provides the best insulation performance among all models.
- **Use HD or ED** where maximum insulation plus hydrocarbon compatibility are required. Nylon construction provides superior resistance to aggressive fluids.
- **Combine thermal modeling with evaporative-loss modeling** for full ROI analysis.
- Integrate Hexa-Cover systems into broader energy-efficiency strategies. Reduced heat loss lowers energy consumption, operational costs, and carbon emissions.
- **Request a Hexa-Cover Technical survey** for site-specific ROI calculations. Facilities with even **modest ΔT 5°C often achieve a payback within months.**

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7. References

1. Aalborg University. *Estimation of Thermal Properties of Hexa-Cover. Jesper E. Nielsen and Michael R. Rasmussen. Department of Civil Engineering, Aalborg University, Denmark.*
2. Exova Canada Inc. *Vapor Sealing Properties of Hexa-Covers in Toluene*. Report No. 13-005-33250-01 (2013).

These references support the comparative analysis between the legacy R114 model and the modern ED,HD and API designs, and provide independent validation of evaporative-loss reduction performance.

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8. Appendices

Appendix A — Regression tables

The following regression tables summarize the slope calculations, intercepts, and R^2 values used to derive U-values for each experiment. These values confirm the stability and linearity of the cooling curve regressions across all test runs.

TEST RUN	Slope	Intercept	R^2			
HD_2	-8.39996E-06	3.393990143	0.992071		Test Run 60 hrs	
	8.85665E-09	0.001102997				
	0.99207141	0.046771812				
	899529.5424	7189				
	1967.813015	15.72667388				
ED_2	-8.31551E-06	3.494727888	0.989964		Test Run 72 hrs	
	9.0197E-09	0.001346393				
	0.989963523	0.062504017				
	849951.2225	8617				
	3320.548791	33.66448353				
API_3	-8.23385E-06	3.538007321	0.988388		Test Run 73 hours	
	1.90316E-08	0.002901129				
	0.988388309	0.068076163				
	187179.1037	2199				
	867.456084	10.19096625				
Open_Water_3	-3.83073E-05	3.484943881	0.991309		Test Run 26.7 Hours	
	1.26817E-07	0.007039885				
	0.991308593	0.09977661				
	91244.93324	800				
	908.3772449	7.964297525				
FOAM_ONLY_3 Foam 4" Lid Inc.	-4.77394E-06	3.769090996	0.975103		Test Run 116.6 Hours	
	1.28997E-08	0.003126436				
	0.975102897	0.092487838				
	136961.1097	3497				
	1171.565346	29.91333835				
Note: The Foam Only background values were calculated were adjusted for the removal of the Foam Lid area in the equation UA module(less lid) = U foam · A module (less lid).						

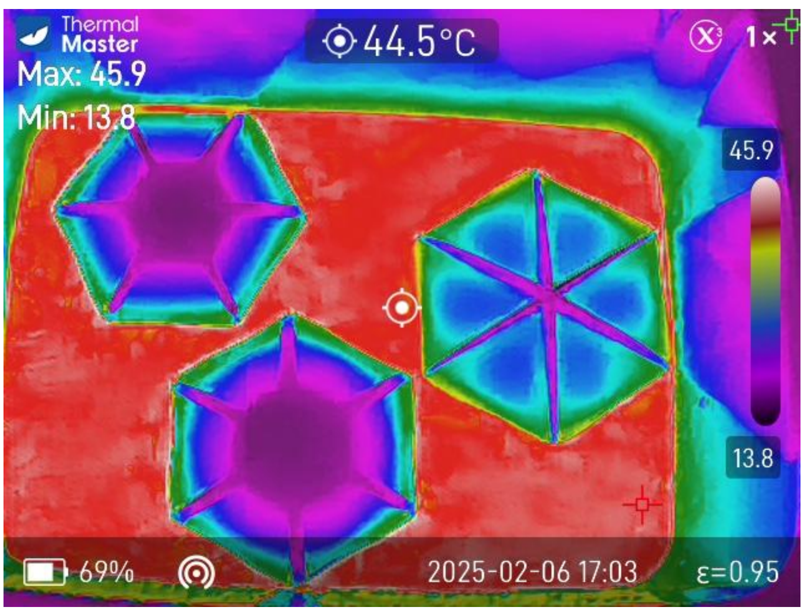
Appendix B — Summary Table of all Values

Model	Flux Reduction compared (to Open Water)	UA	U	R	Notes:
R114 (Aalborg)	74%	Not provided	7.7	0.13	Aalborg Study Values
API net of Foam	87.7%	0.0925	3.1361	0.319	
HD net of Foam	87.2%	0.0962	3.2599	0.307	
ED net of Foam	87.5%	0.0953	3.1969	0.313	
Foam with lid	97.85%	0.1049	0.55	1.82	
Foam Less Lid	N/A	0.0884	0.66	1.51	
Water Open Net of Foam	N/A	0.7534	25.54	0.239	
Water Open Net of Foam Aalborg	N/A	Unknown Area Total	28.6	0.035	Aalborg Study Values
Styrofoam Net	N/A	Unknown Area Total	0.5	2.0	Aalborg Study Values

Appendix C — Examples of Technology Use

API Hexa-Covers Petrochemical Facility Wastewater

Thermal Imaging of R114 (Far Right, API Middle, HD Far Left)



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