Decision 83 01 055 JAN 19 1983

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Application of Thermal Energy Storage, Inc. for exemption from certain sizing and checklist requirements of Decision Nos. 92251, 92501 and 92769	Application 82-11-44 (Filed November 24, 1982)

OPINION ON SOLAR WATER HEATER STORAGE TANK ELIGIBILITY

Thermal Energy Storage, Inc. (TESI) manufactures a unique tank designed to store heat. The heat source may be solar collectors, off-peak electricity or any other. TESI seeks OII 42 eligibility for its tanks. TESI does not manufacture solar collectors, but proposes to design entire solar residential water heating systems which use its tanks. TESI requests the Commission determine that residential water heating systems (which otherwise qualify) with its tanks are eligible to participate in the Commission's demonstration solar financing program (OII 42). This decision grants the requested eligibility under specified conditions.

All other solar systems currently eligible under the OII 42 program store the heat in the water. In contrast, the heat storage medium used in the TESI tanks is a chemical salt dissolved in water. The medium is nearly solid at room temperature. When heat is added to the crystalline salt solution, it melts much as

December 5, 1980, and D.92769, March 3, 1981. In these decisions, we specified a checklist of requirements for domestic solar water heater systems and components, including minimum sizing criteria which were later established. Solar water heaters must meet all sizing and checklist requirements to be eligible for the solar financing program effective March 1, 1981.

Tank Description

TESI tanks are formed from welded aluminum plates. Total tank width is 29 inches to fit through a 30-inch doorway. Height installed is about six feet. Length varies with storage volume. The basic model contains about 225 gallons of salt solution. One model is divided within, to form a salt storage tank and a drainback fluid tank. Salt solution volume and drainback volume if any are labelled on all tanks. An access hatch permits verification of contents.

The tank sides are insulated to about R15 with poly-isocyanurate foam. The foam is protected by a steel cabinet. The tank rests on aluminum channels which conduct heat to the floor, which is often concrete. Insulated supports, provided by decay-resistant or treated wood planks for example, would improve tank performance.

After two years of development at a cost on the order of $1 million, TESI delivered its first purchased tank in 1980. Installations now number about two dozen. The product cannot be considered mature; challenges to engineers and physical chemists remain in the areas of heat exchange efficiency, chemical stability and materials durability.

Supercooling is a term used to describe the retention of a phase (liquid or vapor) in a lower temperature range normally associated with another phase. For example, if water were not ice at 20 deg. F., it would be supercooled below its freezing temperature of 32 deg. F.

Likewise, the TESI salt solution may become supercooled if a seed crystal is not available. Its temperature may drop below 118 deg. F. without crystalization occurring, in which case the stored latent heat is not released for use. For example, one of the test runs provided to the staff included a period of supercooling which delayed thermal discharge of the tank by part of an hour.

TESI's answer to this possibility is a patented "Cold Finger" which it claims reliably initiates the crystalization and heat release process. Its five-year warranty covers proper performance of the salt and "Cold Finger".

CORRECTION

THIS DOCUMENT

HAS BEEN REPHOTOGRAPHED

TO ASSURE LEGIBILITY

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All other solar systems currently eligible under the OII 42 program store the heat in the water. In contrast, the heat storage medium used in the TESI tanks is a chemical salt dissolved in water. The medium is nearly solid at room temperature. When heat is added to the crystalline salt solution, it melts much as

ice does, storing the heat for later release upon solidification. The temperature of freezing and melting of the pure salt (sodium thiosulfate pentahydrate) is 118 deg. F.

The advantage of TESI's tank is that the same amount of heat can be stored in a smaller tank than in a conventional system. This may be particularly attractive in the case of apartment buildings where space for large water storage tanks may be limited. TESI requests that its tanks be granted eligibility in much smaller sizes than is required under OII 42 for storage tanks using only water as the storage medium. TESI states that five gallons of its salt can store as much heat as 20 gallons of water.

This decision approves TESI tanks for OII 42 rebates but at a more conservative sizing of 7.5 gallons of salt solution per 20 gallons of water storage normally required. Also, this decision requires TESI to provide customers a five-year warranty comparable to that regularly offered by other storage tank manufacturers.

Program Background

On September 16, 1980, we issued Decision (D.) 92251 establishing demonstration solar financing programs for Pacific Gas and Electric Company, San Diego Gas & Electric Company, Southern California Edison Company, and Southern California Gas Company. We subsequently modified this decision by D.92501,

December 5, 1980, and D.92769, March 3, 1981. In these decisions, we specified a checklist of requirements for domestic solar water heater systems and components, including minimum sizing criteria which were later established. Solar water heaters must meet all sizing and checklist requirements to be eligible for the solar financing program effective March 1, 1981.

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The tank sides are insulated to about R15 with poly-isocyanurate foam. The foam is protected by a steel cabinet. The tank rests on aluminum channels which conduct heat to the floor, which is often concrete. Insulated supports, provided by decay-resistant or treated wood planks for example, would improve tank performance.

The tank has copper pipe connections, one inlet and one outlet, for each of the two manifolds serving the heat exchangers. In OII 42 installations, the two parallel copper tubes in each heat exchanger are served by the same manifold and behave as a single larger tube.

The entire assembly of the basic tank Model ST-260 weighs about 4,000 pounds when filled. The application applies to this basic model. Other tank designations may relate to piping connection arrangements or to volume. In any case, actual salt volume is labelled on each tank.

Salt Solution Heat Storage Medium

Heat storage concepts utilizing the latent heat of a phase change of the storage medium are not new. They are not presently in large scale or wide use because prior applications ended with decomposition of the phase-change medium after relatively few cycles.

TESI states in its application that Kay Laboratories has patented its solution of the decomposition problem and has for some years marketed medical supplies based on the latent heat principle. TESI purchased the rights to develop the much larger heat storage applications, such as the tank in question here, using the same basic medium which is sodium thiosulfate pentahydrate.

After two years of development at a cost on the order of $1 million, TESI delivered its first purchased tank in 1980. Installations now number about two dozen. The product cannot be considered mature; challenges to engineers and physical chemists remain in the areas of heat exchange efficiency, chemical stability and materials durability.

Supercooling is a term used to describe the retention of a phase (liquid or vapor) in a lower temperature range normally associated with another phase. For example, if water were not ice at 20 deg. F., it would be supercooled below its freezing temperature of 32 deg. F.

Likewise, the TESI salt solution may become supercooled if a seed crystal is not available. Its temperature may drop below 118 deg. F. without crystalization occurring, in which case the stored latent heat is not released for use. For example, one of the test runs provided to the staff included a period of supercooling which delayed thermal discharge of the tank by part of an hour.

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Heat Exchanger Description

Copper tubing is mechanically expanded inside lengths of continuous extruded aluminum fin material.

Each heat exchanger then is built up from about 20 U-shaped fin tubes, formed from lengths of progressively shorter fin-tubes, all nested together.

The exposed ends of the fin-tubes protrude vertically through a tube-sheet located above the highest salt level in the tank.

The tube ends of adjoining fin-tubes are then brazed together with 180 degree bends (copper couplings) to create a continuous, serpentine heat exchanger nominally 120 feet long.

All couplings and fin ends exposed above the tube sheet are then protected from air or water by a layer of epoxy resin poured to cover them in a monolithic block about one inch thick.

With this design, the salt contacts only aluminum, and water contacts only copper. TESI maintains that the salt-aluminum combination is durable, and that galvanic corrosion at the copper-aluminum interface is prevented because it contacts only non-conductive and non-porous epoxy.

Agitator and Controller

In normal operation, the salt in the tank typically is neither entirely liquid nor solid but is in a slush-like condition near the phase-change temperature of 118 deg. F. Since convection improves heat transfer, a motor-driven propeller is used inside the TESI tank to circulate the salt around the heat exchanger fins and to minimize crusting on the fins when heat is withdrawn.

The agitator controller (separate from the solar circulator pump controller) is unique to the TESI tank. Whenever heat is available for storage or is demanded by the load, the controller will turn on the agitator motor. At temperatures much below 118 deg. F., the salt may become solid enough to prevent the propeller from turning. If so, the controller immediately turns the motor off and attempts to restart it every 15 minutes.

The agitator motor rating is 1/6 horsepower or about 125 watts, and the electrical specifications for tank installation call for a dedicated 10 ampere circuit.

It appears that heat transfer and storage capacity would be significantly reduced by failure of the agitation feature. TESI will fully warrant the performance of these components for five years in OII 42 installations.

Installation and Operation

Solar water heater systems designed by TESI are installed and operated as open loops, with potable water flowing through the solar collector panels. Nevertheless, such systems behave as closed loops whenever solar heated water cannot be used immediately. Then the solar heat must pass from the water through a heat exchanger to the salt for storage. The heat must later pass from the salt back through the (same) heat exchanger to heat potable water.

Although no energy would be lost in a perfectly insulated system, the practical effect of a heat exchanger is an energy loss, due to higher temperatures which must be maintained on the supply side to drive a given amount of heat energy through the resistance of the heat exchanger walls.

To improve tank and solar system efficiency, TESI offers an optional valving package for installations in multi-family dwellings having existing hot water recirculation plumbing loops. Such loops are a load on the system even when no hot water is being used. Solar heat not auxiliary heat can be used to offset the loop loss load if this package is installed. Savings from its use could offset the parasitic losses due to the agitator motor.

Sizing

Under existing criteria, for OII 42 eligibility, a solar system must add a minimum storage volume of 20 gallons per bedroom to an existing water heating system.

TESI seeks eligibility for systems using its storage tanks when only five gallons per bedroom are added. TESI appears to base its request on laboratory calculations of the properties of the phase-change storage media and on a thermal storage capacity computer program.

In order to evaluate those performance projections, the ECB staff would require additional detailed workpapers to analyze the methods and assumptions used in their preparation. The staff instead requested representative test data on the performance of the tank as a whole.

No field data was made available, and TESI selected specific tank performance test runs to submit. The tank tests were conducted at TESI facilities, because no standard tank test certification is yet available to the solar community for such chemical storage.

The test parameters included water temperatures ranging from 71 deg. F. to 161 deg. F., flow rates from 10 gal/min to 20 gal/min, and duration of heat transfer up to four hours. In two of

the eight tests, the tank was fully charged with heat starting from a discharged condition; in the other six tests heat was fully released, starting from a fully charged condition.

The ECB compared water temperatures into and out of the tank to determine the heat transferred in each of the test runs.

Since the tank heat capacity varied with the starting and ending temperatures, the average heat capacities (tank specific heat values) were determined above and below the phase-change temperature of 118 deg. F. The overall average heat capacity adopted herein was that found between operating limits chosen at 65 deg. F. and 130 deg. F. The lower limit is representative of California water supply inlet (street) temperatures; the upper limit is representative of observed values achieved under the OII 42 multi-family sizing requirements which permit a 50% reduction in collector area per bedroom compared to single-family system sizing.

Based on the test data, 7.5 gallons of salt solution is equivalent to 20 gallons of water between the same temperatures.

TESI seeks credit for the fact that not all of the heat added to a conventional water tank can be recovered at a usable temperature. ECB staff believes that such a credit would be inappropriate because temperature decay and losses also occur in

TESI tanks, although in the case of TESI tanks the cause may be crystalization on the heat exchanger fins rather than dilution and mixing of tank water. Accordingly, TESI storage installations should be eligible for rebates at the minimum sizing of 7.5 gallons per 20 gallons of water storage.

Warranty

Because of the relatively untested nature of the technology used by TESI, the ECB recommends, and we concur, that warranty terms at least comparable to those offered by any other manufacturer should be a condition of eligibility. The warranty terms are necessary to protect the investment of the ratepayers who pay for the rebate.

TESI is prepared to offer a full five-year warranty covering almost all aspects of its tank. It has offered the same coverage for only one year with respect to corrosion of the heat exchanger.

In contrast, at least one other manufacturer of commonly used tanks with heat exchangers offers a full five-year warranty including the heat exchanger, although the warranty applies only if specified reasonable conditions are met such as those shown in Appendix A. ECB staff recommends that TESI be required to offer a warranty such as that set forth in Appendix A for OII 42 eligibility and we adopt that recommendation.

Monitoring

Solar systems using TESI tanks should be evaluated in the monitoring program now beginning for all solar water heaters which are installed under the OII 42 program.

Disclaimers

Any reference by TESI to this order in its correspondence, marketing literature, or media advertising must contain the following full text of this Disclaimer of Product Endorsement:

> "The California Public Utilities Commission in no way endorses, recommends, or warrants the durability, suitability, or the reliability, or the short- or long-term energy savings performance of this or any other brand of system or component for domestic water heating or any other application".

While this disclaimer is applicable to any system under our demonstration program, we must be certain that this order is not viewed by the public as an implied endorsement.

This Commission specifically disclaims any endorsement by the issuance of this decision of any claim by TESI that TESI's salt storage media will store and release energy as reliably as ordinary water over the lifetime of a properly designed, manufactured and installed water storage tank.

We believe that public hearings would serve no useful purpose. This application should be granted ex parte to the extent provided in the following order.

Findings

1. TESI manufactures rectangular aluminum heat storage tanks measuring about two feet wide by four feet long by six feet high and containing about 225 gallons of chemical storage medium. Models more than four feet long contain up to 360 gallons.

2. The heat storage medium used by TESI is sodium thiosulfate pentahydrate.

3. The medium remains in the tank at all times.

4. The medium is solid at room temperature, melts as heat is added, and freezes again as heat is withdrawn.

5. Heat is transferred into and out of the tank by water passing through five, 4.5-inch-wide, serpentine heat exchangers, each nominally 120 feet long, and all five manifolded together, in parallel.

6. Each of the five heat exchanger fins is a single continuous symetrical extrusion enclosing two parallel 3/8 inch diameter copper tubes carrying potable water at city supply pressure.

7. In TESI-designed systems, the potable city supply water is heated directly in the solar collectors, but the solar heat must pass through a double-wall heat exchanger twice if it is stored before use.

8. Copper and aluminum are in intimate contact in the TESI tank design but those junctions are never in the presence of an electrolyte (chemicals and water).

9. An electric motor of about 1/6 horsepower circulates salt solution inside the tank whenever heat is being transferred into or out of the tank.

10. TESI offers an optional valving package to improve solar system efficiency in buildings served by a recirculating hot water plumbing loop.

11. Test stand data obtained on TESI's premises was provided by TESI to ECB staff for sizing calculations.

12. In TESI's tests, the tank's apparent heat capacity varied with the temperature, direction and rate of heat transfer.

13. 7.5 gallons of salt storage appears equivalent to 20 gallons of water storage for OII 42 applications.

14. TESI voluntarily provides a five-year warranty in the state of Hawaii.

15. TESI has agreed to provide for OII 42 installations a full five-year warranty against defects in material and workmanship or other malfunction or failure to perform covering the tank structure, heat exchanger and manifolds, agitator and agitator control assembly, and the thermal storage media and "Cold Finger". (See Appendix A)

16. For warranty purposes, all OII 42 installations are considered residential, not commerical applications, whether or not the owner is the occupant of the residence.

17. Due to the untested nature of the technology used by TESI, warranty requirements comparable to the best now available are necessary to protect the ratepayers' investment in rebates.

18. A California solar energy assurance labelling program known as CalSEAL provides labels evidencing the payment of a nominal premium for a one-year bonded warranty.

19. TESI offers a service contract to ensure that the maintenance required to keep its five-year warranty in effect is in fact carried out.

Conclusions

1. TESI manufactures an innovative solar heat storage tank utilizing unproven but promising technology and having reduced space requirements due to its sodium thiosulfate pentahydrate storage medium.

2. TESI tanks should be eligible for rebates in sizes of not less than 7.5 gallons salt storage per 20 gallons of water storage required.

3. The Commission should adopt the disclaimers of specific product endorsement contained in this Decision.

4. TESI tanks should be eligible if accompanied by the five-year warranty of Appendix A.

5. TESI's optional feature which improves system efficiency through direct injection of solar-heated water into any existing hot water recirculation loop should be required prospectively for OII 42 eligibility.

6. All system piping connections should comply with the Inspection Checklist requirement of 3/4-inch diameter or larger copper pipe.

7. To protect the ratepayers' investment, eligible TESI tank installations must be covered by a CalSEAL label and a TESI service contract described in Findings 18 and 19.

O R D E R

IT IS ORDERED that:

1. TESI tank installations are eligible for OII 42 rebates when installed in compliance with the preceding Conclusions regardless of the date of installation.

2. Except as granted and provided herein, TESI and its contractors shall adhere to all other currently effective requirements set forth in D.92251, 92501, and 92769 and subsequent orders in this proceeding.

This order is effective 10 days from today.

Date JAN 19 1983, at San Francisco, California.

LEONARD M. GRIMES, JR.
President
PRISCILLA C. GREW
DONALD VIAL
Commissioners

Commissioner Victor Calvo, being necessarily absent, did not participate

I CERTIFY THAT THIS DECISION WAS APPROVED BY THE ABOVE COMMISSIONERS TODAY.

Jack E. Bodovitz, Executive Director

Thermal Energy Storage, Inc.®

January 14, 1983

FULL FIVE-YEAR WARRANTY
ON
TESI THERMAL STORAGE TANK
BY
THERMAL ENERGY STORAGE, INC. (TESI)
10637 Roselle Street
San Diego, CA 92121
(619) 453-1395

1. SCOPE OF COVERAGE

This warranty applies to a new TESI Thermal Storage Tank (the "Tank") purchased by a retail buyer for use on premises in California. This warranty covers the Tanks as a whole including Tank structure, heat exchanger and manifolds, agitator and agitator control assembly, and thermal storage media. Auxiliary equipment specific to system interface and equipment to which the tank is connected on installation are not covered. It extends to the first retail buyer and to any subsequent owner of the premises in which the Tank is installed.

2. FULL FIVE-YEAR WARRANTY ON THE TANK

TESI warrants the Tank to be free from defects in material and workmanship or other malfunction or failure to perform, under normal use and service for five years from the date of sale (if installed by the retail buyer) or completion of initial installation (if installed by a licensed contractor).

A. Repairs. If a defect in material, workmanship, or other malfunction or failure to perform, including leaks or corrosion of the Tank, or aluminum heat exchanger components (hereafter "defect") becomes evident within the first five years from date of sale (if installed by a retail buyer) or date of initial installation (if installed by licensed contractor), the cost of all parts and labor, including transportation, to rectify the defect will be paid by TESI.

In such event, the duration of this warranty is extended while the component or part is not functioning, commencing upon notification by the retail buyer.

B. Refund or Replacement. If the Tank contains a defect which cannot be repaired after a reasonable number of attempts to do so, you, the buyer, may elect either a refund of its price or a replacement without charge. A replacement may consist of a new or factory rebuilt component or part of at least the same quality. A new warranty shall apply to any replacement.

3. CONDITIONS AND EXCEPTIONS

This warranty shall apply only when the solar storage tank and heat exchanger is installed in accordance with local plumbing and building codes, ordinances and regulations, the printed instructions provided with it and good industry practices. In addition, a temperature and pressure relief valve certified by the American Society of Mechanical Engineers must have been installed on the tank and a pressure relief valve certified by the American Society of Mechanical Engineers must have been installed on any closed loop which includes the heat exchangers.

A. This warranty shall apply only when the Tank is used:

1. at temperatures not exceeding the maximum setting of the solar control or 180 degrees F.

2. at fluid pressures not exceeding the working pressure shown on the Tank.

3. with the heat exchanger filled with potable water, free to circulate at all times and with the heat exchanger free of damaging scale deposits.

4. with the heat exchangers filled with an approved heat transfer fluid free to circulate at all times having a pH in the range of 6.5 through 10 and a reserve alkalinity providing satisfactory inhibitor protection.

5. at a flow rate through the heat exchanger not exceeding 30 g.p.m.

6. in a non-corrosive and non-contaminated state atmosphere.

7. in the United States, its territories or possessions, and Canada.

4. WARRANTY PERFORMANCE

A. To Obtain Service. To obtain service on the Tank, notify TESI by telephone or letter, and TESI will provide, service, repair or replacement at the original installation site. To verify that your warranty is still in effect, you must furnish evidence of the date of completion of installation.

B. Provisions for Service. Service will be provided by TESI's factory service organization or by one of TESI's authorized service facilities during normal working hours after you notify TESI giving identification of the equipment, date of completion of installation, and nature of the defect. For the location of the nearest authorized TESI service facility, call or write TESI Customer Service Department at 10637 Roselle Street, San Diego, CA 92121 (619) 453-1395

5. WHAT IS NOT COVERED

A. Exclusions. The above warranties do not apply to:

1. Conditions resulting from a defect in a component or part which is not part of the TESI Tank.

2. INSTALLATION, MAINTENANCE, AND USE OF TESI EQUIPMENT IS REGULATED AND GOVERNED BY THE TESI INSTALLATION MANUAL. THIS WARRANTY IS OF NO FORCE AND EFFECT IF DEVIATION IS MADE FROM MANUAL. ANY DEVIATION FROM MANUAL MAY BE TAKEN ONLY BY TESI UPON INSPECTION AND WRITTEN INSTRUCTIONS FROM TESI ENGINEERING DEPARTMENT.

3. Conditions resulting from failure to provide reasonable and necessary maintenance in accordance with TESI's Operating and Maintenance Instructions.

4. Conditions resulting from any misuse, abuse, negligence, accident or alteration.

5. Normal fading and minor deterioration of exterior surfaces resulting from exposure to the elements, except conditions that do or will affect performance.

B. Limitation on Exclusion from Coverage. Conditions that may occur in the normal operation of the Tank shall not be evoked by TESI to reduce or defeat the coverage of this warranty.

6. OTHER RIGHTS AND REMEDIES

A. Consequential and Incidental Damages. TESI shall not be liable for consequential damages (such as damage to your home, loss of time, inconvenience or loss of use of the product) or any incidental expenses resulting from any breach of express warranties; except that TESI will cover (A) consequential damages to the system in which the improperly functioning component is installed, and (B) incidental expenses incurred to repair or replace, as necessary any component or part injured as a result of such breach. This warranty gives you specific rights to consequential and incidental damages, and you may also have other rights which vary from state to state.

B. No Other Express Warranties. Unless otherwise explicitly agreed in writing, it is understood that these are the only written warranties given by TESI and TESI neither assumes nor authorizes anyone to assume for it any other obligations or liability in connection with the Tank.

C. Implied Warranties. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state, including, in California, implied warranties of merchantabilty and, in certain instances, of fitness for a particular purpose. There are no other warranties, express or implied.

D. Right to Arbitration. Any dispute between the buyer and TESI pertaining to this warranty may, at the option of the buyer, be resolved by arbitration in California according to the rules of the American Arbitration Association.

E. Right to Indemnity. TESI will fully indemnify a licensed contractor who installs the Tank and gives a written warranty as required by the California Solar tax credit regulations, in the amount of any liability to the buyer under such warranty for a breach that is also a breach of the manufacturer's warranty to the buyer.

7. ENDORSEMENT

The TESI Storage Tank, and accompanying warranty, complies with the tax credit regulations of the California Energy Commission.

11. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state. Fill in the following for your own reference. Keep it. Registration is not a condition of warranty. The model and serial number are found on the tank's rating plate.

Model No._____Serial No._____Date Installed._____

Dealer's Name_____

Dealer's Address_____

City and State_____Zip_____

KEEP THIS WARRANTY AND MANUAL POSTED ADJACENT TO THE TANK FOR FUTURE REFERENCE WHENEVER MAINTENANCE, ADJUSTMENT OR SERVICE IS REQUIRED.