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FUEL SAVINGS IN THE HEAVY TRUCKING INDUSTRY THROUGH COOL STORAGE

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ABSTRACT

Overnight idling wastes considerable amounts of fuel, contributes to noise and air pollution and adds significantly to trucker's operating costs. Costs are increased because of both the fuel wasted and the additional maintenance required on the engine as a result of extended idling. In winter, idling not only allows a resting driver to keep warm but prevents cold weather battery, fuel gelling and engine starting problems. In the summer, however, the only reason for overnight idling is to keep the sleeper compartment habitable for the resting driver and diesel engine idling to accomplish this is a massive overkill.

A novel, patented, cool storage system has been developed by the Instatherm Company. This system allows comfortable summer resting conditions for the driver without having to idle the engine or having to start or run any other auxiliary engine. The operating principle is very straightforward -- store "cool" from the truck air conditioning system, while the vehicle is driven on the highway and to use this stored "cool" to air condition the sleeper compartment while the driver rests.

The DOE program, funded through a DOE/National Institute of Standards and Technology, Energy-Related Inventions Award, was designed as a follow-on to a program to develop an engineering prototype for the system. Prior programs were supported by the North Carolina Technological Development Authority and the Instatherm Company. The DOE funded activities were structured so as to complete the evaluation of the engineering prototype, then design and fabricate a production prototype for the system. The progressive goals of these integrated programs have been achieved. Production prototype test units (BUNK COOLER™) have been in operation in several fleets, since the beginning of the 1990 air conditioning season, and have yielded excellent results. Eight hours of comfortable overnight sleep is routinely achieved during the hottest months in the Southern States. Invariably, the BUNK COOLER equipped trucks are the only quiet vehicles in a sea of polluting, noisy, fuel wasting vehicles, "idling the night away" at truck stop rest areas.

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BACKGROUND AND INTRODUCTION

Air conditioning systems typically deliver cold/dehumidified air at temperatures ranging from 40-60°F, depending on the particular application. Direct cool storage from such air conditioning systems is generally very difficult since storage technology is usually directed towards ice formation or sensible heat removal from water tanks. Ice formation requires specialized cooling equipment, not typically associated with air conditioners, and is energy inefficient because of the low temperature requirements. Sensible heat removal from water tanks can be achieved at air conditioning temperatures, but at 8-10 times the weight of storage material as compared to ice. Sensible heat storage is typically used in large buildings where swimming pool sized storage tanks can be economically constructed.

A class of compounds termed gas hydrates or clathrate hydrates has been known for over a hundred years but has found only limited use. These compounds are ice like in nature, which is understandable since 70% of their make-up is water, with the remaining 30% being in the form of clathrate forming gas. Many of these clathrate forming gases are readily available and non-toxic.

The interesting characteristic of these clathrates is that they freeze at well over 32°F and have heats of formation in the 120 Btu/lb range. This is close to the latent heat of fusion of ice at 144 Btu's/lb. The above baseline characteristics for gas clathrates make them ideal candidates for phase change cool storage directly from operational air conditioners.

The development, by the Instatherm Company, of an innovative cool storage system, U.S. patent #4,922,998 issued May 8th 1990, has led to a very practical small tube method for using clathrates in cool storage. This method involves packaging the clathrate forming cool storage material in sealed, mass produced, aluminum tubes. These tubes are presently manufactured to contain pressurized gas mixtures and are fully approved for consumer use.

The use of a multiplicity of these tubes provides extensive surface contact area and allows direct air-side mounting of the cool storage module in the a/c cold air duct. This methodology forms the basis for an economical cool storage technology with many applications. Fig.1 shows a generic phase diagram for gas clathrates. A tabulation showing the upper invariant points for a selected group of gas clathrates is shown in Table 1. The upper invariant point is of most significance, since it is at this point that decomposition and (theoretically) formation occur.

Fig. 1
Gas Clathrate Phase Diagram

Upper Invariant Point		Gas	
Temperature (°C)	Pressure (psig)	Formula	Name
8.3	-6	CCl ₃ F	CFC 11
8.3	0	CHCl ₂ F	HCFC 21
9.9	40	CHBrF ₂	HBFC 22B1
12.1	48	CCl ₂ F ₂	CFC 12
12.1	19	SO ₂	Sulfur Dioxide
13.1	19	CH ₃ CClF ₂	HCFC 142b
14.7	7	CH ₃ Br	Methyl Bromide
14.9	48	CH ₃ CHF ₂	HFC 152a
16.2	67		Cyclopropane
16.3	97	CHClF ₂	HCFC 22
17.9	27	CH ₂ ClF	HCFC 31
20.5	57	CH ₃ Cl	Methyl Chloride
22.8	103	C ₂ H ₅ F	HFC 161

Table 1.
Upper Invariant Points for selected Gas Clathrates

Ref. Davidson, D.W. "Clathrate Hydrates," Water - A comprehensive treatise, ed. Felix Franks, Vol 11, Plenum Press, N.Y. 1973

The above table is by no means a complete listing, but it is illustrative of the variety of gases for which clathrates are known. The preponderance of fluorinated compounds in the listing is deliberate, since these materials are generally very low in toxicity, are usually readily available and form excellent clathrates. While the universal availability of a number of the fully halogenated chlorofluorocarbons, CFC's makes them good clathrate candidates, the non-fully halogenated chlorofluorocarbons fluorocarbons (HCFC's), and the fluorocarbons themselves (HFC's), that make up the bulk of the fluorocarbons in Table 1, will become the fluorocarbons of choice for clathrate formation well before the mid 1990's. The reason for this is that International protocols have been recently enacted that will curtail production of several fully halogenated CFC's (such as CFC 12, presently found in most consumer and automobile a/c systems) because of ozone concerns. The anticipated replacement for CFC 12 is HFC 134a and this material forms a clathrate with an upper invariant point of approximately 10⁰C. At the present time this material has limited availability and is expensive.

ENGINEERING PROTOTYPE

Module Evaluation

Three of four modules, that make-up the engineering prototype, were completed prior to the start of this DOE program. The fourth module required repackaging, because of inadequate insula-

tion and this was accomplished under the DOE program. The module contains 38, 1" diameter x 24" long copper tubes fabricated, in-house, from .005" thick copper sheet. A photograph of a completed 38 tube module (3000 Btu capacity) is shown below in Fig.2.

Fig.2
3,000 Btu Engineering Module

A test station, based on a standard laboratory type cooling bath and a heater core to provide the liquid to air heat exchange, was fabricated to facilitate the bench testing of individual modules. This bench testing showed the following:

* While clathrate could be readily formed in the module at 42°F inlet air temperature when the nucleators were activated, clathrate formation would not occur at even 32°F inlet air without such activation. The lowest air temperature, generally achievable on vehicle A/C systems, ranges between 38 & 42°F thus the

requirement for nucleators for each of the tubes is mandatory.

* A solid clathrate pack was evident in most of the tubes in a module within 2 to 3 hours from the start of the charging process. A solid pack was determined by an inability to move the nucleators.

* Discharge capacity, for the 38 tube module, was determined to be between 2,700 and 3,000 Btu's.

Cooling Capacity Required for Truck Sleeper Compartment

Two modules were selected as being sufficient to determine the cooling requirement for truck sleeper compartments on (1) hot sunny days, (2) hot partially sunny days, and (3) hot summer evenings. On a use basis, the summer evening requirement is by far the most important since drivers schedule most of their extended rest periods in the evening.

Prior to the actual in-sleeper testing, a suitable end cap and manifold system had to be fabricated to assure uniform air flow from a single blower through the two modules. With the vehicle battery as the power source, a simple resistance speed control was also fabricated. This controller allowed control of the air flow through the modules at between 30 and 70 cfm.

All cooling capacity tests were done on Class 8 Volvo/GM Integral Sleepers, owned by the Cone Mills Corporation. These tests were done with the truck parked at the Cone Transportation Center in Greensboro, N.C. and the modules charged in the laboratory prior

to installation in the truck. The two units were installed on the sleeper compartment bunk as shown in Fig 3.

Fig. 3
Static Test System.

Sleeper temperatures in the cooled unit were compared with the sleeper temperatures in a nearby, uncooled, sleeper truck on the Cone Transportation Ltd. Testing on a hot/cloudless summers day, with the outside air temperatures reaching 95°F, the uncooled sleeper compartment sat at a temperature of 110°F. In the cooled unit, the two modules held the sleeper at 90°F for the seven hour test period. Testing on a partially cloudy summers day, with the outside air temperature reaching 89°F, the uncooled sleeper sat at 107°F while two modules in the cooled sleeper were capable of holding 80°F in the compartment. On a warm summer evening, with an ambient temperature of 87°F, the uncooled sleeper sat at 91°F while the cooled sleeper sat at a comfortable 75°F. This temper-

ature was held at an air flow rate of 39 cfm and a steady outlet temperature from the cool storage array of 58°F. On this basis two modules will be more than sufficient evening and overcast daytime requirements but a full 4 module system will be necessary if full sun use is to be encountered often. A marketing decision is necessary here, taking into account cost and end use patterns.

In the course of the above testing, some driving was done with the modules mounted directly on the bunk. Movement of the modules was very evident and no simple means could be identified to hold down these modules while installed in this way. This necessitated a redesign of the packaging arrangement, for baggage compartment mounting, prior to in-truck clathrate formation testing.

Repackaging of Engineering Unit

A Class 8 Volvo/GM Integral Sleeper, owned by Cone Mills Corporation of Greensboro, North Carolina was selected as the vehicle to conduct the road testing. This vehicle was of the conventional type (Class 8 trucks come in two truck body styles, cabover and conventional) and had a separate evaporator and heater core for the sleeper box heating and cooling. Secondary evaporators and heaters for the sleeper box are becoming common in the newer vehicles. This situation makes control of cold air flow to the cool storage module on charge somewhat easier, as cold air flow is not greatly influenced by the cab settings selected by the driver.

Four cool storage modules were stacked together for installation in the truck as shown in Fig.4

Fig.4
Module Stacking Arrangement

Insulated inlet and outlet manifolds were fabricated from $1/16$ " PVC sheet and $1/2$ " styrofoam insulation. Since the seal between the manifolds and the modules retained only air, at a few inches of head, closed cell weatherproofing strip tape was used to make this seal. Banding was used to hold the modules together and to hold the inlet and outlet manifolds in place. With the inlet manifold attached air flow distribution between the modules was measured. This flow distribution was as follows.

Air Flow (CFM) Through Each Module

				Total Flow CFM
(1)	(2)	(3)	(4)	
11.2	9.9	9.4	10.5	41
16.2	13.3	13.3	16.1	59
23.8	21.2	20.3	23.8	89

Modules (2) and (3) were on the inlet side of the pack and at the 89 cfm total flow rate carried 47% of the total flow with modules (1) and (4) carrying 53%. No additional flow balancing was deemed necessary. Fig.5 shows the four modules plus inlet and outlet manifolds in position.

Fig.5
Modules plus Manifolds

The class 8 sleeper truck used for the on-the road test is shown in Fig.6

Fig.6
Volvo / GM Integral Sleeper

The modules were stacked individually in the baggage compartment of this truck then banded together. The end manifolds were also banded into position. Truck components undergo severe vibration and motion when on the road, but simple banding was sufficient to maintain integrity of the pack and manifolds throughout the road test. A photograph showing the cool storage unit installed in the baggage compartment is shown in Fig.7

Fig. 7
Cool Storage Unit in Truck

A schematic drawing showing the interconnections between the cool storage system and the sleeper unit is shown in Fig. 8. By closing the flaps on the sleeper compartment vent, the sleeper blower circulated cold air from the air coil over the cool storage system, tubes and back through the storage blower which was set against a charge. For discharge, the storage blower was actuated, the flaps opened and the sleeper blower turned off.

Fig. 8
Schematic of Installed Cooled Storage Unit

The road testing covered a 54 hour trip from Greensboro - Nashville - Memphis - Nashville - Greensboro in October 1989. Over this time period the cool storage system was on charge for a total of 16 hrs and provided cooling for 15.8 hrs. This cooling was provided during separate 8.6 and 7.2 hour sleeping cycles. Typical charging conditions showed approximately 44°F inlet air temperature to the cool storage system and 52°F outlet temperature from the unit. Typical discharge temperature from the unit was 58°F throughout the sleeping period. On the second sleep cycle, the ambient temperature fell below 55°F after 4.2 hrs. At this point the unit started to function as a 55°F heater and it did this for the final 3 hrs of the 7.2 hr discharge. Testing on cool evenings does not give capacity data for the unit and this will have to await warmer weather. However, the charge data was

fairly typical since daytime temperatures in the cab get well over 85°F and a/c was required. This testing confirmed the ability of the clathrate system to store "cool" from the vehicle a/c unit and deliver this stored "cool" to the sleeper compartment when needed. As an added bonus clathrate was shown to form very well as the air cooled off and the unit performed as a low grade heater. Capacity was the only data lacking from the in-vehicle testing but this had been established earlier and the production prototype program was therefore initiated.

PRODUCTION PROTOTYPE COOLING SYSTEMS

Sizing of Production Prototype Units

The in-vehicle and road tests, involving the engineering test unit installed in a Class 8 Volvo/GM Integral Sleeper Truck, indicated a considerable difference in the cooling requirements for daytime and evening use for the sleeper box. Daytime requirements being more than double that required for the evening usage. Examination of driver use patterns showed that while sleeper boxes were occasionally used during the day, the predominant long term use, greater than 95% was for evening sleeping. As a result of the above, the cool storage unit was sized to handle the eight hour evening sleeping requirement. It should also be noted that the cool storage system is simply an accessory to the sleeper cooling system and that at any time the standard sleeper cooling system can be operated with the truck engine idling. The production prototype cool storage unit was therefore

sized in the 7,000 - 8,000 Btu range as opposed to the 12,000 Btu for the engineering prototype system.

Production Prototype Fabrication

Thin walled copper tubing, that was used in the engineering system, was not found to be commercially available, nor were production techniques available at tube fabricators to produce such a product. In fact, the lap seal soldering technique, that the Instatherm Company had developed for the .005" walled copper tubes, was of itself of interest to the tube fabricators. Because of the product development required, copper tubes were shelved in favor of 1" diameter x 6" long aluminum canisters, production coated with a barrier layer. Suppliers for both the canisters (Peerless Tube) and the closure valves (Bespak) were identified and the components ordered. It should be noted that even here the 6" long tube was 50% longer than the 4" standard canister on the market. Peerless tube felt that the 6" version was possible using standard industrial practice and they were successful in producing this product.

Clathrate studies continued with a view to raising the nucleation temperature and the equilibrium temperature for the phase change material. Using mixtures of HCFC's nucleation temperatures in excess of 50°F were achieved with phase change temperatures between 54°F and 60°F. Filling techniques were also developed to allow a consistent fill for the small tubes.

A simple insulated box, occupying 2.3 cubic feet in volume was designed to hold the cool storage array. A test model of this container was built in the workshop while drawings were submitted

to local fabricators for quotations. A local fiberglass company (Tri-State) was selected to fabricate a test unit. A second approach, with respect to an insulated container to hold the cool storage arrays, was to use a suitably sized ice chest. A reasonably good fit was found in a 54 quart Coleman ice chest. This chest appears to be suitably sized for a number of installations and will hold the required number of phase change tubes. However, measurements taken on variety of sleeper trucks indicates a desirable goal of less than a $12\frac{1}{2}$ " height for the insulated array containers. The height goal is readily achievable for the purpose made units but has not been found in any suitable sized ice chest located to date. Even the Coleman ice chest is 1" too large to meet the height goal. Purpose made containers will cost more than production ice chests but will probably be required for widespread utilization.

Manufacture of Production Prototypes:

The selection of 6" long x 1" diameter seam free aluminum canisters, suitable for mass production and high rate filling techniques, necessitated the development of a small scale production line to both simulate the large scale manufacturing processes and allow the limited production necessary for the evaluation program. This filling line was established and was capable of producing 200 or more filled tubes per day. At 450 tubes per completed cooling system this line was more than adequate to handle the production prototype requirements. Two assembly technicians were required for this filling line.

Timing constraints necessitated the use of a 54 quart ice chest

as the insulated box to hold the first cooling arrays fabricated from the line. Purpose made fiberglass boxes were ordered from a local supplier, and these boxes were to be used for production prototype two onwards.

Packaging of Cool Storage Tubes:

While loose tubes held in a supporting framework (within the insulated container) is a possible packaging method, the uncertainties of air flow through such a pack is of concern. Practical tolerance limits on the insulated box plus tapers necessary for fabrication together with a requirement to prevent vibration between tubes, necessitate a more structured approach. Individual arrays of 150 tubes each were therefore fabricated as self-supporting units. This was accomplished via an array packing fixture. A photograph showing several of these arrays is shown in Fig.9.

Fig. 9
Cooling Arrays

Shaped styrofoam inserts were installed in the major flow channels around the edges of the close packed array. These flow channels would carry a disproportionately high air flow if left open. Three arrays were then aligned within the insulated container and firmly located in position with 1/8" foam rubber packing and the unit sealed.

Air Flow Distribution & Balancing:

Before an operational system could be designed for integration into a truck sleeper, air flow characteristics within the cool storage unit and through the associated ducting, needed to be established. While the pressure drop characteristics of the actual in-line 3 array module is fixed and invariant, the headers, inlets, and feed ducting are variables that need to be specified.

Flow testing revealed that with 1.2" headers at each end of the insulated fiberglass box, and a 4" to 5" tapered inlet, the unit had an overall pressure drop ranging from 0.9" of static water head at 150 cfm to 0.2" of water at 60 cfm. Three inch diameter flexhose added approximately 0.05" of water head per foot at 100 cfm with each 90 degree bend adding a similar amount. The pressure drop fell considerably when 4" flexhose was used, 0.013" per foot at 100 cfm and approximately 0.03" per 90 degree bend. Three inch internal diameter swept tees added 0.3" of static pressure when making the turn at 100 cfm and 0.12" when flowing through the tee without having to make the turn.

With a central flow inlet, a 1.2" header and only one array of tubes in place, a scan was made of the air flowing through

the channels created by the close packed array of tubes. With the exception of the central flow channel, air flows were within plus or minus 14% of each other. This was considered acceptable considering that the addition of the other two arrays would further balance flows and that the complications of adding additional flow balancing devices would yield minimal overall gains.

FABRICATION AND TESTING OF PRODUCTION PROTOTYPE #1:

Fabrication

A photograph of the three thermal storage arrays used in prototype is show in Fig.9 these arrays were then packaged in a 54 quart cooler as shown in Fig.10. It should be noted again that future production prototypes will utilize purpose made cases rather than the above cooler. Air inlet and outlet openings were cut into the cooler, a blower attached and the lid sealed down.

fig. 10
Prototype cooler

The cooling system was tested for capacity in the laboratory. Rocking the unit was used to simulate motion in the vehicle although this could by no means duplicate the more vigorous motion within a truck. Capacities of the order of 7,000 Btu's were achieved, and nucleation occurred very readily. A charge / cooling cycle is shown in Fig.11.

Fig. 11
Charging /Cooling Cycle

Fig. 12
Nucleation Requirement

The necessity of active nucleation is apparent from Fig.12. In this instance at inlet temperatures of 4.5°C, nucleation did not occur until the nucleators were actuated. This nucleation is seen at 420 minutes into the test with a sharp rise in outlet temperatures. Following the lab testing, the unit was installed in a 1987 Peterbilt sleeper truck, to provide some preliminary installation and performance data.

Design of Overall System:

There are as many sleeper air duct arrangements as there are truck models on the market and this presents a unique set of problems in the design of an installation package for the cooling system. Obviously it is highly desirable to have one cool storage package that is universally applicable to sleeper trucks and many designs were considered with respect to this goal. No design fulfilled the above requirement completely, but a simple T branching from the main duct to the sleeper, with flap valve control of the air to the T and a flow through type blower on the cooling unit (by flow through, it is meant a blower that allows reverse air flow through it), with little back pressure, proved to be the most versatile system design. A tubeaxial blower was found to be the best compromise, to date, for the blower requirement although it's head limitations, while it is in the cooling mode, require careful attention to ductwork pressure drops.

Preliminary Performance Data:

Installation of the test unit under the bunk of a 1987 Peterbilt truck, with walk in sleeper, was accomplished. The unit was simply T'd into the sleeper outlet ducting from the truck cooling system and a removable cap fabricated to cover the sleeper outlet and duct cold air over the Instatherm Unit. With the cap removed, air flow was allowed into the sleeper box either from the existing cooling system or from the Bunk Cooler when it's fan was turned on. A simple on-off switch controlled the fan. Testing in this manner required more driver participation than was desirable for future units. Fig.13 shows a photograph of the truck used and Fig.14 shows the unit installed under the bunk.

Fig.13
1987 Peterbilt Sleeper Truck

Fig. 14
Unit installed under Bunk

Initial results from on the road operation indicated less cooling performance than anticipated, the Bunk Cooler being able to keep the resting driver comfortable for 3-4 hrs on 80°F evenings. However, during this initial testing, the driver was sleeping with the curtain open, between the cab and the sleeper compartment, thus the Bunk Cooler was being forced to cool the entire cab. As soon as the driver closed the curtain for sleep periods, the Bunk Cooler functioned exactly as planned. It stored "cool" from the cold air side of the vehicle a/c system and was able to keep the driver comfortable at rest stops for up to 8 hours, at outside temperatures as high as 90°F. This cooling was done without having to idle the truck diesel engine. At these rest areas, all the adjacent trucks generally had their engines idling

to keep their respective drivers cool, both consuming fuel and polluting the local environment. The above tests included a successful evening rest period in mid-July in the Florida Panhandle -- close to the worst case conditions the unit will have to handle. Considering the fact that the Bunk Cooler was designed for the smaller non-walk-in sleeper, the results were excellent. The results confirmed the size, performance and practicality of the unit and demonstrated its ability to eliminate excess idling.

System Control:

For the second production prototype onwards, a driver acceptable control system needed to be developed. The use of a small tubaxial blower on the Bunk Cooler, with its relatively low head, necessitated control valves to be of low pressure drop, while integration of such a valve into the ducting system necessitated a compact valve. These two requirements tend to conflict with one another. Through many iterations, an air deflector valve was developed that met these criteria. This valve was 4" square in cross section but had a variety of end adapters fabricated to allow valve insertion into variously shaped ducts. The valve was tensioned by a coil spring and a lever operated sheathed steel cable was used to position the deflector plate in one of three positions:

1. **Bypass:** where the flow is ducted away from the cool storage system so that the standard vehicle system can be used.

2. **Charge:** when cold air from the vehicle system is ducted through the Bunk Cooler to freeze the phase change material.

3. Sleep: when air is circulated through the Bunk Cooler to melt the phase change material and cool the bunk area.

Fan speed was controlled via resistors and a two position switch, providing 9 or 12 V to the blower. The 12 V setting was needed in almost all cases to provide sufficient air flow for the driver. The required air flow was in the 50 cfm range. At a 58 - 60°F outlet temperature from the Bunk Cooler, a thermostat does not appear to be necessary for driver comfort.

A photograph of the deflector valve and the control unit is shown in Fig. 15.

Fig. 15
Deflector Valve & Control Unit

FINAL PRODUCTION PROTOTYPES

While the DOE funds were exhausted with the fabrication and preliminary testing of the first production prototype, private placement funding picked up the program and carried it through more extensive prototype fabrication and testing. As an example of this, Fig.16 shows this purpose made insulated fiberglass encased unit and Fig.17 shows this unit installed in a 1990 Peterbilt sleeper truck. This truck was on a vehicle that was on a long term lease by a plastics fabricator from a major rental company and was in daily operation. In Fig.17 the unit is mounted in the storage compartment under the bunk and the deflector valve is clearly seen mounted directly into the a/c unit blower. The unit is working exceptionally well as can be seen from the tabulated data in appendix 1.

Fig. 16
Final Production Prototype

Fig. 17
Final Production Prototype Installed

CONCLUSION

Through an integrated Entrepreneur / North Carolina Technological Development Authority / DOE-NIST / Private Placement funded program a viable cooling system, that stores cool directly from air conditioned air, has been developed. This system will eliminate the extremely wasteful and highly polluting practice of idling truck diesel engines to provide cooling for a resting driver at truck stops.

Appendix 1.

BUNK COOLER REPORT SUMMARY SHEET

BUNK COOLER SERIAL # 90/003

Date - 1990	Location	Start of Sleep Period		End of Sleep Period		Hours Slept	Hours of Effective BUNK COOLER Operation	Neighboring Trucks Running Engines
		Time	Outside Temp Of	Time	Outside Temp Of			
9/5/90	Dumas, AR	2:00 AM	75	10:00 AM	90	8	8	Yes
9/6/90	Monrovia, IN	10:30 PM	74	6:30 AM	79	8	8	Yes
9/7/90	Franklin, KY	2:00 AM	78	10:00 AM	91	8	8	Yes
9/10/90	Nashville, TN	12:30 AM	72	8:30 AM	74	8	8	No
9/10/90	VillalRica, GA	9:00 PM	70	10:00 AM	90	13	13	Yes
9/14/90	Eldorado, AR	3:00 AM	72	9:00 AM	84	6	6	Yes
9/15/90	Houston, TX	5:30 AM	78	1:30 PM	91	8	8	Yes
9/19/90	Arkadelphia, AR	6:30 PM	75	2:30 AM	70	8	8	Yes
9/30/90	Birmingham, AL	11:00 PM	70	7:00 AM	65	8	8	No
10/3/90	Chillicothe, TX	12:00 AM	75	8:00 AM	68	8	8	Yes
10/4/90	Dallas, TX	8:00 PM	72	4:00 AM	66	8	8	No

END

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