

HEAT TRANSFER PROPERTIES OF HYDROGEN PEROXIDE



Since heat transfer involves a combination of phase, thermodynamic, and transport properties, as well as some consideration of chemical kinetics, this section on heat transfer properties has been included as part of the physico-chemical properties. This section is designed as a reference guide and summary of the various experimental heat transfer studies that have been conducted on propellant-grade hydrogen peroxide solutions.

Heat Transfer Properties of Hydrogen Peroxide

Experimental heat transfer studies on 90 w/o H_2O_2 solutions (reported in Ref.1) indicated that a high flux heat transfer, usually associated with boiling, was obtained from a 347 stainless steel surface to liquid 90 w/o H_2O_2 as a result of the H_2O_2 decomposition mechanism. This decomposition, which simulates boiling by the liberation of gas bubbles at the heat transfer surface, is accelerated with temperature increase of the surface. Figure 2.24 illustrates the magnitude of this effect, as well as the lesser effect of pressure and liquid temperature, in terms of heat flux. Because of these effects, the study showed that the temperature difference between the surface and liquid was not significant.

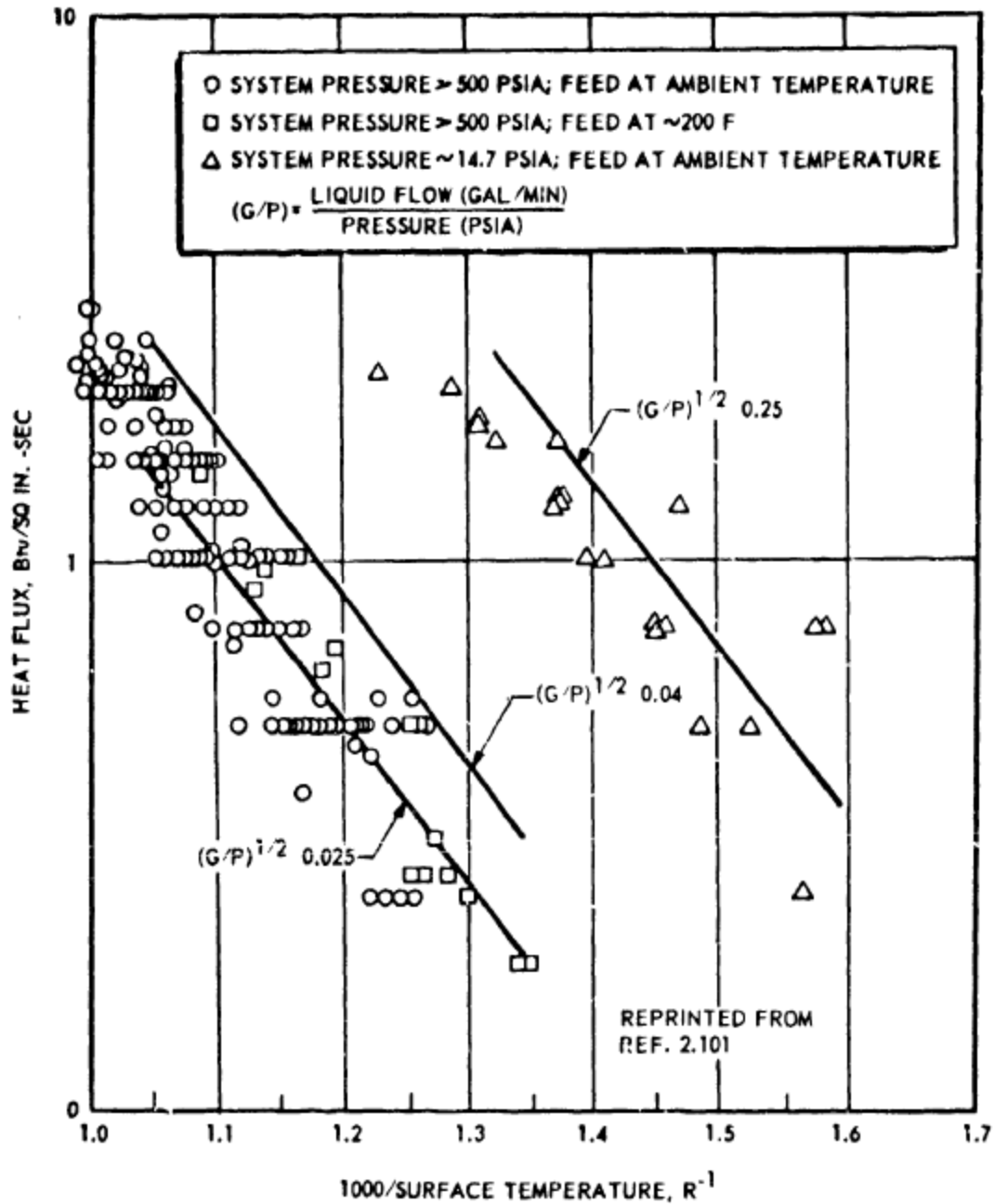


Figure 2.24. Heat Flux From a 347 Stainless-Steel Surface to 90 w/o Hydrogen Peroxide as a Function of Surface Temperature

An extension of these studies to high fluid velocities and moderately high temperature differences was reported in Ref. 2. At high flowrates and high Reynolds numbers (where decomposition is limited by the short liquid residence time), the resultant heat transfer data agreed with that expected for forced convective heat transfer. It was found that heat fluxes as

high as 11.75 Btu/sq in.-sec (at liquid velocities of ~ 80 ft/sec) could be obtained with 90 w/o H₂O₂ without complication by decomposition of the hydrogen peroxide. A least-square fit of the heat transfer data obtained on 90 w/o H₂O₂ resulted in the following expression:

$$(N_{Nu})_f = 0.0287 (N_{Re})_f^{0.8} (N_{Pr})_f^{1/3}$$

The standard deviation of the experimental data from this equation was 10.2 percent.

Heat transfer properties of hydrogen peroxide studies in the forced convective region of both 90 w/o and 98 w/o H₂O₂ were reported in Ref. 3. Peak heat fluxes of 7.80 Btu/sq in.-sec were measured for 90 w/o H₂O₂ at fluid velocities of 41.3 ft/sec. The results obtained for peak heat flux of 98 w/o H₂O₂ at the conditions investigated are shown in Fig. 2.25. The correlation of the data on 98 w/o H₂O₂ with the Dittus-Boelter, Colburn, and Sieder-Tate equations (Fig. 2.26 through 2.28, respectively) indicated better agreement of the data with the Dittus-Boelter relationship. It has been suggested, however, that some of the apparently low heat transfer coefficients, indicated by the correlations of Fig. 2.26 through 2.28, may be due to slight scaling (oxidation) of heat transfer surfaces.

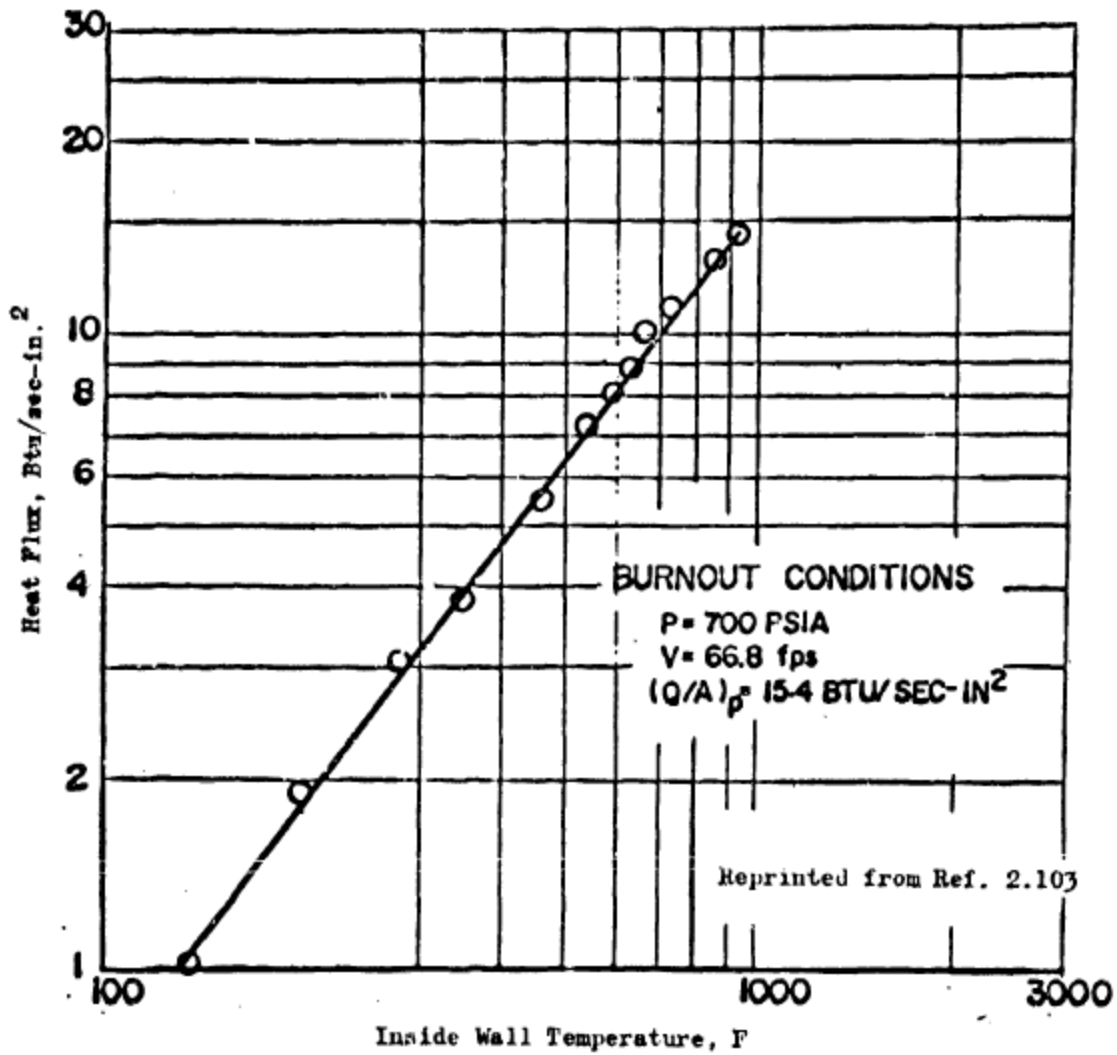


Figure 2.25. Typical Curve of Heat Flux vs Inside Wall Temperature
(98 w/o Hydrogen Peroxide 1-1/2 Inches Upstream
From Exit of Heated Section)

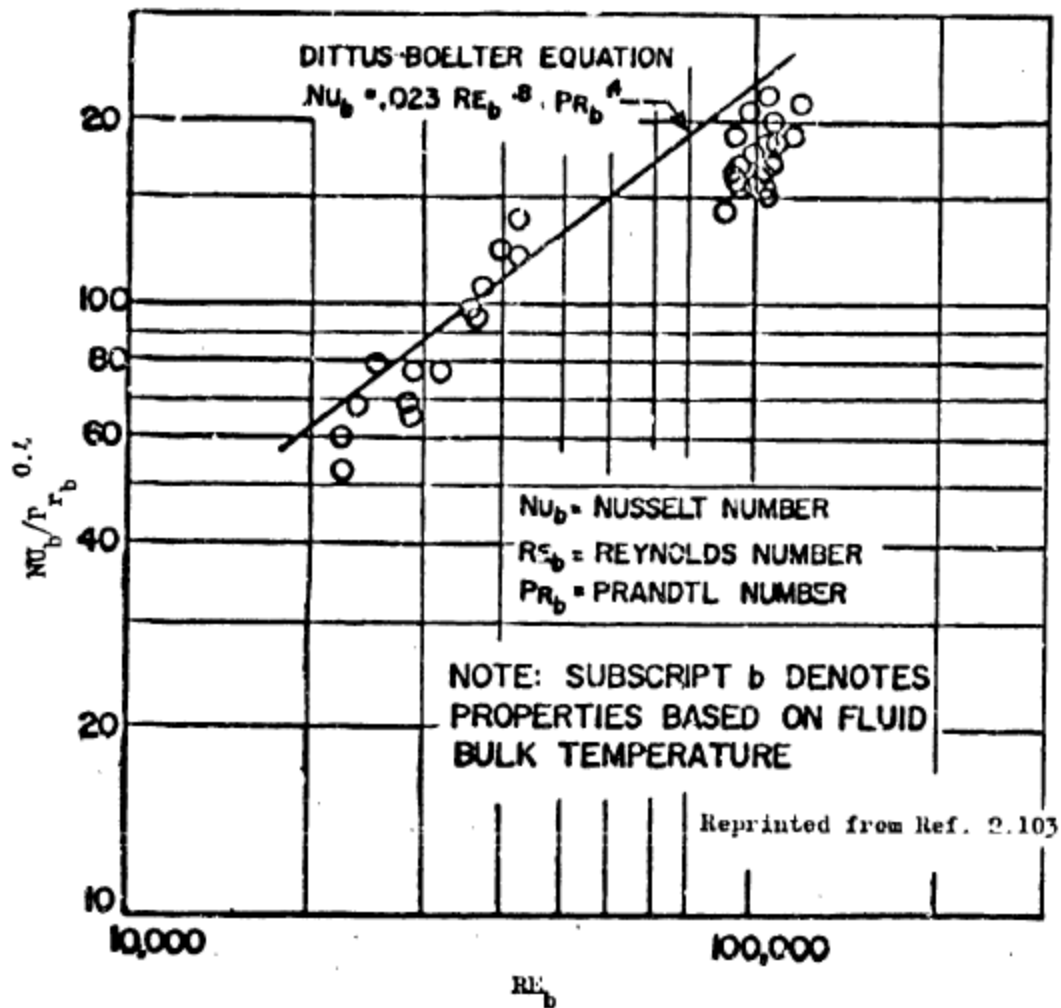


Figure 2.26. Correlation of Heat Transfer Coefficients of 98 w/o Hydrogen Peroxide With Dittus-Boelter Equation (Convective Region)

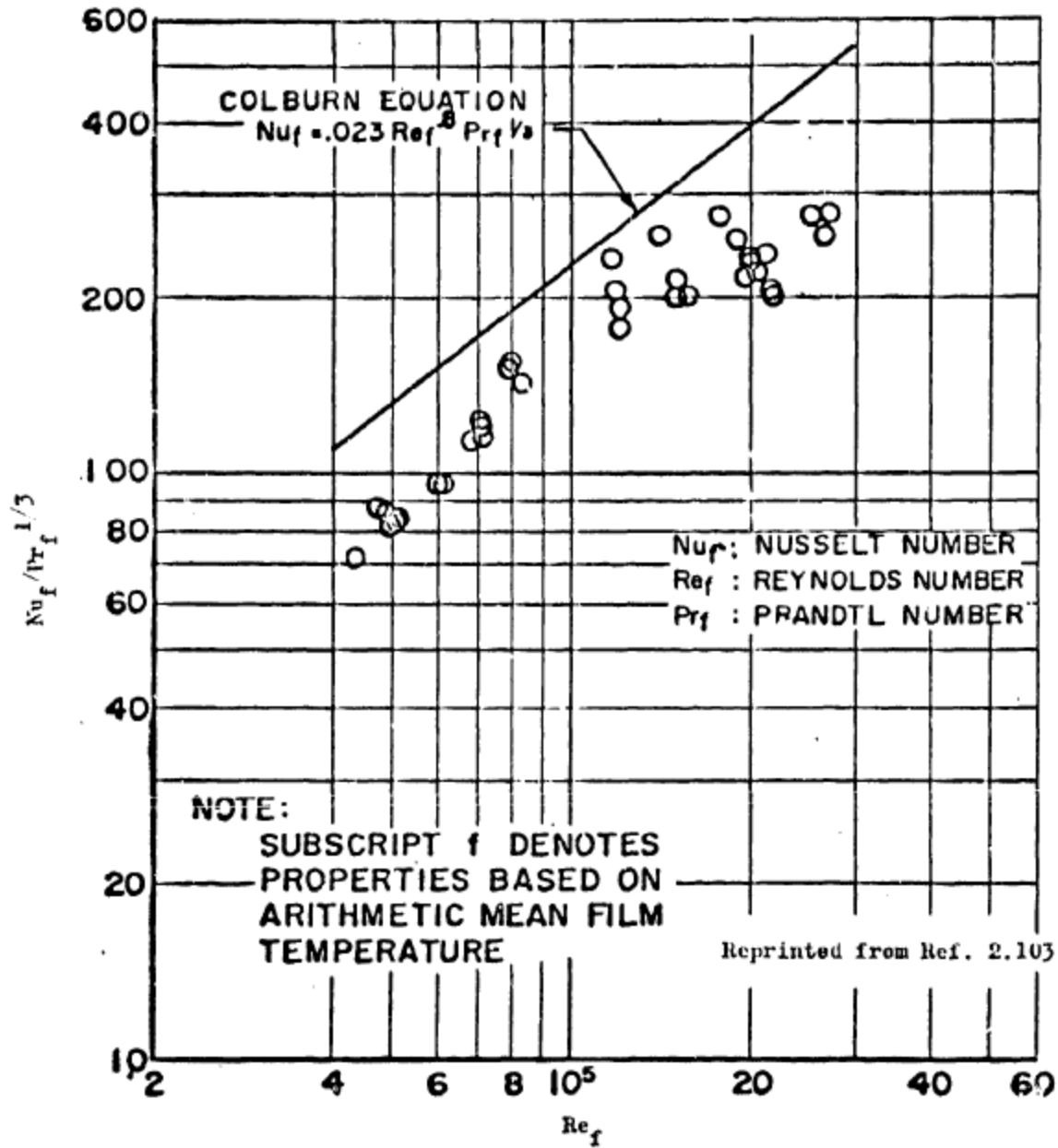


Figure 2.27. Correlation of Heat Transfer Coefficients of 98 w/o Hydrogen Peroxide With Colburn Equation (Convective Region)

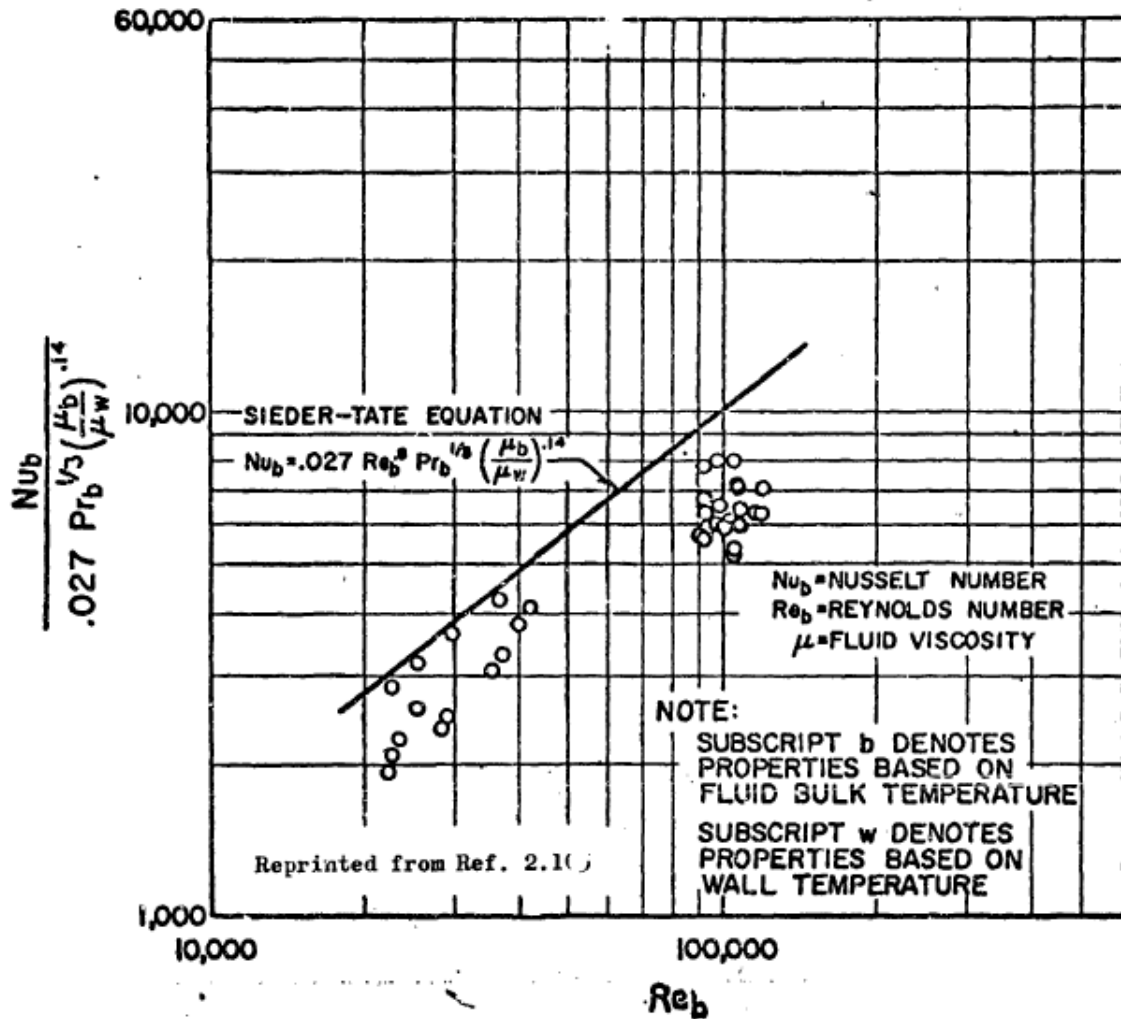


Figure 2.28. Correlation of Heat Transfer Coefficients of 98 w/o Hydrogen Peroxide With Sieder-Tate Equation (Convective Region)

A current study on the use of 98 w/o hydrogen peroxide for regeneratively cooled rocket engines has reported (Ref. 4) that during 18 experimental tests (with fluid velocities from 25 to 198 ft/sec, pressures from 2000 to 4700 psia, and feed temperatures from 60 to 240 F), heat fluxes up to 48.2 Btu/sq in.-sec were achieved. It was found that the heat flux at burnout (under the conditions tested) was directly proportional to the fluid velocity by the relationship: $heat\ flux_{bo} = 0.21 \times velocity$. These results indicated good correlation of heat flux and fluid velocity with the studies of Ref. 2 and 3. During these tests, no appreciable difference in heat transfer could be associated with feed temperature, and no detectable decomposition was evident. Four similar tests with 90 w/o hydrogen peroxide indicated no discernible differences from the results of the

98 w/o hydrogen peroxide tests. As in the studies of Ref. 3, the Dittus-Boelter correlation was found to represent the data more closely than either the Colburn or Sieder-Tate relationships. The results of all of these studies have shown that hydrogen peroxide has coolant properties comparable to those of water. Of course, the difficulty in its use as a regenerative coolant lies in the limited stability of the H_2O_2 at higher temperatures. As a result, various bulk liquid temperature limits have been suggested and established in the use of H_2O_2 as a regenerative coolant. These limits range from established (Ref. 5) maximum allowable temperatures of 225 F (with a 105 F rise over inlet temperature) to suggested operating limits (Ref. 6) of 250 F (with red line conditions at 275 F). More detailed analysis of minimum safe design criteria of H_2O_2 regenerative-cooling systems, based on the available data from various sources, is presented in terms of ultimate heat flux and fluid velocity in Ref. 7. Additional analysis of transient heat transfer for an H_2O_2 regeneratively cooled engine modal is given in Ref. 8.

Source : <http://www.diyspaceexploration.com/heat-transfer-properties-of-hydrogen-peroxide/>