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Datasheet for the decision of 7 October 2025

Case Number: T 1301/23 - 3.3.02

Application Number: 16787466.8

Publication Number: 3368630

IPC: C09K5/04, F25J1/02

Language of the proceedings: EN

Title of invention:
LOW-TEMPERATURE MIXED--REFRIGERANT FOR HYDROGEN PRECOOLING IN LARGE SCALE

Patent Proprietor:
Linde GmbH

Opponent:
L AIR LIQUIDE SOCIETE ANONYME POUR L ETUDE ET L EXPLOITATION DES PROCEDES GEORGES CLAUDE

Headword:
LINDE / MIXED--REFRIGERANT / HYDROGEN LIQUEFACTION

Relevant legal provisions:
EPC Art. 56, 83, 123(2)

Keyword:
Amendments - added subject-matter (no)
Sufficiency of disclosure - (yes)
Inventive step - (yes)

Decisions cited:
G 0003/14, T 0593/09

Catchword:

Beschwerdekammern
Boards of Appeal
Chambres de recours

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Case Number: T 1301/23 - 3.3.02

D E C I S I O N
of Technical Board of Appeal 3.3.02
of 7 October 2025

Appellant: (Opponent)	L AIR LIQUIDE SOCIETE ANONYME POUR L ETUDE ET L EXPLOITATION DES PROCEDES GEORGES CLAUDE 75 Quai d'Orsay 75007 PARIS (FR)
Representative:	Air Liquide L'Air Liquide S.A. Direction de la Propriété Intellectuelle 75, Quai d'Orsay 75321 Paris Cedex 07 (FR)
Respondent: (Patent Proprietor)	Linde GmbH Dr.-Carl-von-Linde-Straße 6-14 82049 Pullach (DE)
Representative:	Lu, Jing Linde GmbH Intellectual Property EMEA Dr.-Carl-von-Linde-Straße 6-14 82049 Pullach (DE)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 2 June 2023 concerning maintenance of the European Patent No. 3368630 in amended form.**

Composition of the Board:

Chairman	M. O. Müller
Members:	M. Maremonti
	R. Romandini

Summary of Facts and Submissions

I. The appeal by the opponent ("appellant") lies from the opposition division's interlocutory decision, according to which European patent No. 3 368 630 ("the patent") as amended in the form of auxiliary request 1, the claims of which were filed during the oral proceedings of 9 February 2023, and the invention to which it relates meet the requirements of the EPC.

II. Claim 1 of auxiliary request 1 found allowable by the opposition division reads as follows:

"*1. A method for liquefying a feed gas stream, the method comprises the steps of:*

providing a feed gas stream (11) comprising a feed gas, wherein said feed gas stream (11) has initial temperature,

precooling said feed gas stream (11) from said initial temperature to an intermediate temperature in a precooling step by a closed loop cooling cycle with a precooling refrigerant stream (41) yielding a precooled feed gas stream (12),

cooling said precooled feed gas stream (12) in a cooling step from said intermediate temperature to a temperature below the boiling temperature or the critical temperature of said gas,

wherein said feed gas stream (11) comprises hydrogen and is precooled in said precooling step to a temperature in the range of 80 K to 120K [sic], *said precooled feed gas stream (12) is brought into contact with a catalyst being able to catalyse the conversion of ortho hydrogen to para hydrogen.* [sic]

wherein said precooling refrigerant stream (41) is a refrigerant composition consisting of:

(A) 10 mol. % to 23 mol. % nitrogen, and

27 mol. % to 33 mol. % methane, and

11 mol. % to 38 mol. % ethane, and

16 mol. % to 30 mol. % n-butane, isobutane, isopentane, 1-butene or isobutane, or 20 mol. % to 40 mol. % propane,

provided that the sum of the concentrations of the above-mentioned components does not exceed 100 mol %, or

(B) the first component is nitrogen in an amount of 8 mol. % to 18 mol. %; the second component is methane in an amount of 30 mol. % to 36 mol. %; the third component is ethane or ethylene in an amount of 28 mol. % to 35 mol. %; and the fourth component is n-butane or iso-butane in an amount of 22 mol% to 28 mol% or n-pentane or isopentane in an amount of 15 mol. % to 25 mol. %; or. [sic]

(C) the first component is nitrogen in an amount of 15 mol. % to 25 mol. %; the second component is methane in an amount of 28 mol. % to 35 mol. %; the third component is ethane or ethylene in an amount of 23 mol. % to 36 mol. %; and the fourth component is iso-butane in an amount of 21 mol% to 28 mol% or iso-pentane in an amount of 15 mol. % to 22 mol. % or propane in an amount of 30 mol% to 40 mol%; or

(D) the first component is nitrogen in an amount of 18 mol. % to 25 mol. %; the second component is methane in an amount of 28 mol. % to 34 mol. %; the third component is ethane in an amount of 20 mol. % to 27 mol. %; and the fourth component is 1-butene in the

range 20 mol. % to 28 mol. %, or propane in the range of 30 mol% to 40 mol%, or

(E) four components, wherein a first component is nitrogen in the range of 5 mol. % to 35 mol. %, a second component is argon in the range of 20 mol. % to 40 mol. %, a third component is ethane or ethylene in the range of 10 mol. % to 40 mol. %, and a fourth component is one of isobutane, isopentane or 1-butene in the range of 10 mol. % to 35 mol. %, or propane or propylene in the range of 10 mol. % to 45 mol. %; provided that the sum of the concentrations of the above-mentioned components does not exceed 100 mol%; or

(F) five components, wherein a first component is nitrogen in the range of 5 mol. % to 35 mol. %, a second component is argon in the range of 20 mol. % to 40 mol. %, a third component is ethane or ethylene in the range of 10 mol. % to 40 mol. %, and a fourth component is one of isobutane, isopentane or 1-butene in the range of 10 mol. % to 35 mol. %, or propane or propylene in the range of 10 mol. % to 45 mol. %; and a fifth component is one of n-butane, isobutane, propane, propylene, n-pentane and isopentane, wherein said the [sic] *fifth component is different from said fourth component; provided that the sum of the concentrations of the above-mentioned components does not exceed 100 mol%.*"

III. The opposition filed invoked the grounds under Article 100(a) to (c) EPC. Reference was made to the following documents, *inter alia*:

D51: Nayak and Venkatarathnam, "*Performance of an auto refrigerant cascade refrigerator operating in gas refrigerant supply (GRS) mode with nitrogen-hydrocarbon and argon-hydrocarbon refrigerants*", Cryogenics 49, 2009, 350-59

D52: Frank *et al.*, "*Argon liquefaction by means of a mixed refrigerant cycle*", DKV Tagung 2009, Berlin, AA I 07

D64: Berstad and Walnum, Integrated design for demonstration of efficient liquefaction of hydrogen (IDEALHY): Report on Modelling of Large-Scale High-Efficiency IDEALHY Hydrogen Liquefier Concept, 2013, pages iii, iv, 1-13

IV. The opposition division's conclusions in the appealed decision included the following.

- The subject-matter of auxiliary request 1 complied with Article 123(2) and 83 EPC and involved an inventive step in view of D64 taken as the closest prior art.

V. In its statement of grounds of appeal, the appellant contested the opposition division's reasoning and maintained that the claimed subject-matter extended beyond the content of the application as filed, was insufficiently disclosed and lacked an inventive step.

VI. In its reply to the appeal, the patent proprietor ("respondent") rebutted the appellant's arguments.

VII. The parties were summoned to oral proceedings as per their requests. In preparation for the oral proceedings, the board issued a communication under Article 15(1) RPBA.

VIII. Both parties filed a further submission after the board's communication.

IX. Oral proceedings before the board were held on 7 October 2025 by videoconference in the presence of both parties.

X. Final requests relevant to the decision

The appellant requested that the appealed decision be set aside and that the patent be revoked.

The respondent requested that the appeal be dismissed, implying that the patent be maintained in amended form on the basis of the claims of auxiliary request 1 found allowable by the opposition division (main request in appeal).

XI. As regards the parties' submissions that are relevant to the decision, reference is made to these in the reasons for the decision set out below.

Reasons for the Decision

Main request (auxiliary request 1 found allowable by the opposition division) - claim 1 - added subject-matter under Article 123(2) EPC

1. The amendments to claim 11 of the application as filed as included in claim 1 of the main request have been highlighted by the board by taking into account the dependency of claim 11 on claims 1 to 9 of the application as filed:

"*1. A method for liquefying a feed gas stream, the method comprises the steps of:*

providing a feed gas stream (11) comprising a ***feed*** *gas, wherein said feed gas stream (11) has initial temperature,*

precooling said feed gas stream (11) from said initial temperature to an intermediate temperature in a precooling step by a closed loop cooling cycle with a precooling refrigerant stream (41) yielding a precooled feed gas stream (12), *cooling said precooled feed gas stream (12) in a cooling step from said intermediate temperature to a temperature below the boiling temperature or the critical temperature of said gas,*

wherein said feed gas stream (11) comprises hydrogen and is precooled in said precooling step to a temperature in the range of 80 K to 120K [sic]***, said precooled feed gas stream (12) is brought into contact with a catalyst being able to catalyse the conversion of ortho hydrogen to para hydrogen.*** [sic]

wherein said precooling refrigerant stream (41) ~~comprises or~~ is a refrigerant composition consisting of:

(A) 10 mol. % to 23 mol. % nitrogen, and

27 mol. % to 33 mol. % methane, and

11 mol. % to 38 mol. % ethane, and

16 mol. % to 30 mol. % n-butane, isobutane, isopentane, 1-butene or isobutane, or 20 mol. % to 40 mol. % propane,

provided that the sum of the concentrations of the above-mentioned components does not exceed 100 mol %, or

(B) the first component is nitrogen in an amount of 8 mol. % to 18 mol. %; the second component is methane in an amount of 30 mol. % to 36 mol. %; the third component is ethane or ethylene in an amount of 28 mol. % to 35 mol. %; and the fourth component is n-butane or iso-butane in an amount of 22 mol% to 28 mol% or n-pentane or isopentane in an amount of 15 mol. % to 25 mol. %; or. [sic]

(C) the first component is nitrogen in an amount of 15 mol. % to 25 mol. %; the second component is methane in an amount of 28 mol. % to 35 mol. %; the third

component is ethane or ethylene in an amount of 23 mol. % to 36 mol. %; and the fourth component is iso-butane in an amount of 21 mol% to 28 mol% or iso-pentane in an amount of 15 mol. % to 22 mol. % or propane in an amount of 30 mol% to 40 mol%; or

(D) the first component is nitrogen in an amount of 18 mol. % to 25 mol. %; the second component is methane in an amount of 28 mol. % to 34 mol. %; the third component is ethane in an amount of 20 mol. % to 27 mol. %; and the fourth component is 1-butene in the range 20 mol. % to 28 mol. %, or propane in the range of 30 mol% to 40 mol%, or

(E) four components, wherein a first component is nitrogen in the range of 5 mol. % to 35 mol. %, a second component is argon in the range of 20 mol. % to 40 mol. %, a third component is ethane or ethylene in the range of 10 mol. % to 40 mol. %, and a fourth component is one of isobutane, isopentane or 1-butene in the range of 10 mol. % to 35 mol. %, or propane or propylene in the range of 10 mol. % to 45 mol. %; provided that the sum of the concentrations of the above-mentioned components does not exceed 100 mol%; or

(F) five components, wherein a first component is nitrogen in the range of 5 mol. % to 35 mol. %, a second component is argon in the range of 20 mol. % to 40 mol. %, a third component is ethane or ethylene in the range of 10 mol. % to 40 mol. %, and a fourth component is one of isobutane, isopentane or 1-butene in the range of 10 mol. % to 35 mol. %, or propane or propylene in the range of 10 mol. % to 45 mol. %; and a fifth component is one of n-butane, isobutane, propane, propylene, n-pentane and isopentane, wherein said the [sic] *fifth component is different from said fourth component; provided that the sum of the concentrations*

of the above-mentioned components does not exceed 100 mol%."

2. The appellant raised three objections of added subject-matter against claim 1 of the main request.

2.1 First objection

2.1.1 The appellant submitted that claim 1 mentioned an intermediate temperature and a temperature of 80 K to 120 K. These two temperatures did not necessarily coincide, i.e. the intermediate temperature could be higher than 80 K to 120 K. Hence, according to the appellant, claim 1 covered an embodiment in which the temperature of 80 K to 120 K was not achieved by the closed loop cycle with the claimed refrigerant compositions defined in claim 1 but by other unspecified means. This embodiment was not disclosed in the application as filed, thus resulting in an extension of subject-matter. This interpretation of claim 1 was reinforced by the disclosure on page 13, lines 1 to 7 of the application as filed stating that the intermediate temperature could be outside the range between 80 K and 120 K.

2.1.2 This objection is not convincing. The board concurs with the respondent's view that the wording of claim 1 (see above) unambiguously defines the intermediate temperature achieved by the feed gas stream in the precooling step to be in the range of 80 K to 120 K. In fact, claim 1 first defines the precooling step as a step in which the feed gas stream is brought to an intermediate temperature and then specifies the latter to be in the stated range. Even if the term "*intermediate temperature*" is not repeated, this is the only sensible reading of claim 1 and therefore no added subject-matter results from the inclusion of the temperature range from 80 K to 120 K.

2.2 Second objection

2.2.1 The appellant further submitted that refrigerant compositions B, C and D were not directly and unambiguously disclosed in the application as filed in combination with the liquefaction of streams comprising hydrogen, especially in view of the fact that compositions B, C and D were not included in the claims as filed but only mentioned in the description of the application as filed.

2.2.2 This objection is also not persuasive. As submitted by the respondent, the whole application as filed is directed to refrigerant compositions to be used *inter alia* in methods for liquefying streams comprising hydrogen, see e.g. page 1, lines 2 to 4; page 11, lines 7 and 8; page 13, lines 17 to 20; the paragraph bridging pages 17 and 18; and claim 12 of the application as filed. All these passages of the application as filed are very general and do not limit the liquefaction of streams comprising hydrogen to the use of specific refrigerant compositions of the invention. Compositions B, C and D as defined in claim 1 are identified in the application as filed as compositions of the invention (see page 5, lines 8 to 24 for composition B, page 6, lines 5 to 19 for composition C and page 8, lines 6 to 19 for composition D) and thus are directly and unambiguously linked *inter alia* to the liquefaction of streams comprising hydrogen.

2.3 Third objection

2.3.1 The appellant additionally submitted that the application as filed did not disclose the use of refrigerant compositions B, C and D as defined in claim 1 to cool a feed gas stream comprising hydrogen to a temperature in the claimed range from 80 K to

120 K. It noted that composition B was disclosed on page 5 of the application as filed only in combination with a cooling temperature between 100 K and 120 K, and composition D on page 8 of the application as filed only in combination with a cooling temperature between 85 K and 90 K, while no cooling temperature was specified for composition C disclosed on page 6 of the application as filed.

2.3.2 The board does not find this objection convincing either. As submitted by the respondent, the temperature ranges mentioned on page 5 for composition B and page 8 for composition D are stated to be preferred (see the wording "particularly useful") rather than being mandatory. Moreover, the board concurs with the respondent's view that various passages of the application as filed directly and unambiguously disclose that the claimed cooling temperature between 80 K and 120 K is achieved by using refrigerant compositions of the invention, without referring thereby to any specific composition (see for example page 3, lines 1 to 3, page 13, lines 2 to 3 and 17 to 20, page 17, lines 10 to 12, and claim 14 of the application as filed).

2.4 In view of the above reasons, the board concludes that none of the appellant's objections under Article 123(2) EPC is convincing.

Main request (auxiliary request 1 found allowable by the opposition division) - claims 1 and 3 - sufficiency of disclosure under Article 83 EPC

3. The appellant raised three objections of insufficiency of disclosure against claims 1 and 3 of the main request.

Claim 3 of the main request reads as follows:

"*3. A method for liquefying a feed gas stream, the method comprises the steps of: providing a feed gas stream (11) comprising a feed gas, wherein said feed gas stream (11) has initial temperature* [sic], *precooling said feed gas stream (11) from said initial temperature to an intermediate temperature in a precooling step by a closed loop cooling cycle with a precooling refrigerant stream (41) yielding a precooled feed gas stream (12), cooling said precooled feed gas stream (12) in a cooling step from said intermediate temperature to a temperature below the boiling temperature or the critical temperature of said gas, wherein said feed gas is selected from the group comprised of hydrogen and helium, wherein said feed gas stream (11) comprises hydrogen and is precooled in said precooling step to a temperature in the range of 85 K to 120 K, yielding said precooled feed gas stream (12), said precooled feed gas stream (12) is brought into contact with a catalyst being able to catalyse the conversion of ortho hydrogen to para hydrogen, and wherein said precooling refrigerant stream (41) is a refrigerant composition consisting of five components, wherein a first component is nitrogen, a second component is argon, a third component is ethane or ethylene, a fourth component is one of n-butane, isobutane, 1-butene, propane, propylene, n-pentane and isopentane; and a fifth component is one of n-butane, isobutane, propane, propylene, n-pentane and isopentane, wherein said the fifth component* [sic] *is different from said fourth component.*"

3.1 First objection

3.1.1 According to the appellant, a refrigerant mixture (i.e. the precooling refrigerant stream (41) of claim 1) had to be optimised as a function of two parameters, namely, the minimum temperature to be achieved for the gas to be cooled and the "minimum temperature approach" of the heat exchanger, in order to carry out the method of claim 1. The appellant referred to D51, comparing in figures 6 and 8 various four-component refrigerant mixtures having been optimised in terms of concentration of the components to achieve a certain refrigerant temperature at the heat exchanger outlet. Figure 6 of D51 used a minimum temperature approach of 0.2 K whereas figure 8 used 5 K. It could be observed that for the same refrigerant outlet temperature, refrigerant mixtures with substantially different concentrations of the components had to be used. Especially the ethane concentration varied considerably when the outlet temperature varied from 90 K to 120 K. The patent did not give sufficient information as regards the minimum temperature approach to be used and the minimum temperature to be achieved. Thus an undue burden was placed on the skilled person trying to identify compositions suitable for carrying out the claimed method.

3.1.2 This objection is not convincing. As submitted by the respondent, the "minimum temperature approach" of a heat exchanger is the difference between the hot inlet and the cold outlet temperatures of the feed stream or between the cold inlet and the hot outlet temperatures of the refrigerant. The board concurs with the respondent's view that the design and optimisation of a heat exchanger in terms of this parameter are part of common general knowledge and do not impose any undue burden on the skilled person.

Moreover, claim 1 specifies six different refrigerant compositions (compositions A to F) used to precool a feed stream comprising hydrogen to a temperature between 80 K and 120 K. The appellant has not provided any evidence that by selecting a refrigerant composition as claimed, the skilled person would not have been able to cool a stream comprising hydrogen within the claimed temperature range. It is further noted that claim 1 does not require any refrigerant optimisation.

3.2 Second objection

3.2.1 The appellant further argued that the patent did not specify the location in the closed loop cycle at which the claimed refrigerant composition should be met. This was a problem since the cooling cycle represented in figure 2 of the patent included partial condensation steps such as the one occurring in compressor 63b. Liquid and gas exiting the separator downstream of compressor 63b had different compositions. This was illustrated again in D51, particularly in figures 3, 14 and 16. Thus, the claimed compositions might be encountered at one point of the cycle but not at another point. Therefore, the skilled person did not know whether they were working within or outside of the claimed scope. According to the appellant, this case was analogous to the one dealt with in decision T 593/09 since claim 1 contained an ill-defined parameter (the refrigerant composition) and the skilled person would not be able to identify the measures needed to solve the problem underlying the patent. In particular, the skilled person would have to test the compositions at the compressor, the evaporator and the phase separator of the cooling cycle, the compositions having different minimum temperatures and different minimum temperature approaches, and find out how the composition could be optimised. This constituted an undue burden.

3.2.2 This objection is also not convincing. As submitted by the respondent, claim 1 requires that refrigerant compositions A to F are used to precool the feed gas stream within a closed loop cooling cycle. The fact that claim 1 does not specify the location within this cycle where the stated refrigerant composition has to be encountered, such that the skilled person might possibly not know whether they were working within or outside of the claimed scope, may at most constitute a clarity problem at the claim boundaries but does not result in any insufficiency of the disclosure. Since the features objected to by the appellant were already present in the granted claims (see claims 9 and 12 as granted and their back reference to claims 1 to 7 as granted) they are not open to clarity objections (see G 3/14, OJ EPO 2015, 102, Order).

Decision T 593/09 cannot support the appellant's case either. In fact, claim 1 does not mention any problem to be solved apart from requiring the claimed compositions A to F to be capable of cooling a feed gas stream comprising hydrogen to a temperature between 80 K and 120 K. As stated above, the appellant has provided no evidence showing that compositions A to F are unsuitable for this purpose.

3.3 Third objection

3.3.1 The appellant additionally argued that compositions A and B of claim 1 and the composition of claim 3 included n-butane. The latter was included in compositions A and B of claim 1 at concentrations up to 30% while in claim 3 no upper limit was defined. Since the triple point of n-butane was 134.9 K, n-butane would be solid at the claimed temperatures. The same applied to n-pentane with its triple point of 143.4 K and to a certain extent to iso-butane and iso-pentane with their triple points of 113.6 K and 113.3 K respectively, which were also included in the compositions of claims 1 and 3. A refrigerant containing solids would not be capable of working.

Paragraph [0076] of the patent disclosed that the refrigerant mixtures had been designed for clog-free plant operation with margins to potential mixture or component freeze out; however, the patent contained no teaching as to how this design should be put into practice. In particular, claim 3 covered compositions with very high concentrations of freezing components, thus placing an undue burden on the skilled person trying to identify working compositions among the huge number of claimed possibilities.

3.3.2 This objection is not convincing either.

Claims 1 and 3 require that the compositions defined therein act as a refrigerant able to precool gas streams comprising hydrogen to a temperature falling in a defined range (80 K to 120 K for claim 1 and 85 K to 120 K in claim 3). This functional feature of claims 1 and 3 limits the claimed methods to refrigerant compositions meeting this functional requirement. This means that mixtures containing solid components are not covered by the subject-matter of claims 1 and 3 since they are incapable of meeting the above-mentioned refrigeration requirement.

For sufficiency of disclosure, what is decisive is whether the skilled person is provided with enough guidance by the patent to select compositions meeting this functional requirement without any undue burden.

Paragraph [0076] of the patent invoked by the appellant confirms that the refrigerant mixtures of the invention are designed for clog-free plant operation with margins to potential mixture or component freeze out (solidification). The same paragraph further specifies that this result is obtained through selected and effective melting-point depression. In fact, as argued by the respondent, the components pointed out by the appellant, n-butane, n-pentane, iso-butane and iso-pentane, are not used alone in the claimed methods but in admixture with further components, this leading to melting point depression. As further submitted by the respondent, at least paragraph [0024] and the claims of the patent (see also the application as filed, the paragraph bridging pages 5 and 6, and the claims) disclose concrete examples of compositions falling under the subject-matter of claims 1 and 3 of the main request, and including, *inter alia*, n-butane, n-pentane, iso-butane and iso-pentane. The appellant did not provide any proof that these example compositions were not able to work as refrigerants according to the claimed method, e.g. with regard to component freeze out. The board is convinced that by way of these example compositions, the patent provides the skilled person with enough guidance to carry out the invention as defined in claims 1 and 3 without undue burden.

3.4 For these reasons, the board concluded that the subject-matter of claims 1 and 3 of the main request is sufficiently disclosed, thus meeting the requirements of Article 83 EPC.

Main request (auxiliary request 1 found allowable by the opposition division) - claim 1 - inventive step under Article 56 EPC

4. Closest prior art

4.1 In line with the appealed decision (page 11, point 17.3.1), both parties indicated document D64 as the closest prior art.

4.2 D64 discloses (pages 1, 2, 7 and 8; figures 6 and 8) a method for liquefying a feed gas stream comprising hydrogen, the method comprising precooling said feed gas stream from an initial temperature to an intermediate temperature in a precooling step by a closed loop cooling cycle with a refrigerant stream yielding a precooled gas stream, wherein said precooled feed gas stream is brought into contact with a catalyst being able to catalyse the conversion of ortho hydrogen to para hydrogen. As intermediate temperature, D64 mentions a temperature of 80 K (page 8) or a temperature between 100 and 140 K (page 1).

5. Distinguishing features

It was common ground that the subject-matter of claim 1 differs from the disclosure in D64 in the refrigerant composition being used for the precooling step, which, according to claim 1, is one of compositions A to F.

6. Objective technical problem

6.1 At the oral proceedings, both parties agreed to the formulation of the objective technical problem as the provision of a suitable refrigerant for the precooling step taught in D64.

7. Obviousness of the claimed solution

7.1 Claim 1 proposes one of compositions A to F as a solution to the above-mentioned objective technical problem.

7.2 The appellant referred to document D52, which discloses (abstract, pages 4, 5 and 8, figure 4) the use of various refrigerant mixtures for liquefying argon. In particular, mixtures M2 and M3 as defined on page 5 of D52 fell under compositions A and C of claim 1. Additionally, figure 4 of D52 showed that mixtures M2 and M3 were able to cool argon to a temperature between 100 K and 120 K, i.e. a temperature within the range required by claim 1. The appellant provided numerical simulations carried out with the software HYSYS (statement of grounds of appeal, pages 7 to 13) demonstrating that the refrigerant performance of mixtures M2 and M3 in terms of heat exchange were approximately the same for argon and hydrogen and remained the same even when scaling up the process. The appellant submitted that such numerical simulations were accessible to the skilled person. Therefore, the skilled person would have expected that the performance disclosed for argon in D52 would have been maintained when liquefying hydrogen. The appellant noted that even though D52 concerned laboratory tests, it referred in the abstract to natural gas liquefaction, i.e. an industrial process. When looking for suitable refrigerants, the standard procedure followed by a skilled person comprised modelling and laboratory tests. Moreover, the author of D52 was an expert in the field of refrigeration; therefore, the skilled person would have consulted D52 when seeking a solution to the posed technical problem. Additionally, hydrogen was a very explosive gas; hence, it would have been clear to the skilled person that laboratory tests for the liquefaction of hydrogen should be conducted with a neutral gas, i.e. argon as in D52.

7.3 At the oral proceedings, the appellant further argued that D52 disclosed a precooling step followed by a main cooling step, referring in this respect to figure 2 of D52. The mention in section 2.1 of D52 of R404A as the refrigerant for the precooler concerned a previous test stand used in the laboratory where the method taught in D52 had been developed. In other words, D52 disclosed that the refrigerant for the precooling step had been changed by replacing R404A with *inter alia* compositions M2 or M3. According to the appellant, this was confirmed by the fact that argon had a boiling point of 87 K; since figure 4 of D52 indicated that a temperature between 100 K and 120 K was achieved with compositions M2 and M3, it was clear that these compositions were used in the precooling step rather than in the main cooling step of D52. Therefore, the skilled person would have been prompted by D52 to use refrigerant mixtures M2 and M3 in the precooling step of D64 and would thus arrive at the subject-matter of claim 1 in an obvious way.

7.4 The appellant's arguments are not convincing for the following reasons.

7.4.1 As pointed out by the respondent, D64 concerns a method for liquefying hydrogen on a large scale. Therefore, when looking for a refrigerant to be used in the precooling step of such a method, the skilled person would have turned to documents relating to hydrogen liquefaction. D52 discloses (abstract) first experiments run for liquefying argon. According to D52 (abstract), these first experiments were performed in view of the increasing demand for liquefied gases such as nitrogen, argon or natural gas. Hydrogen liquefaction is neither mentioned nor hinted at in D52. Contrary to the appellant's view, D52 does not contain any indication that argon liquefaction was tested in D52 with the aim of simulating hydrogen liquefaction due to the explosive nature of hydrogen. This argument by the appellant amounts to mere speculation. In the absence of any indication that the method disclosed in D52 would be useful for hydrogen liquefaction, let alone on a large scale, the skilled person would not have consulted D52 when seeking a solution to the above-mentioned objective technical problem.

7.4.2 Even if it were assumed for argument's sake that the skilled person would have consulted D52, the board concurs with the respondent's view that D52 discloses exclusively the use of refrigerant R404A for the precooling step of the described method, i.e. a refrigerant different from the compositions defined in claim 1 of the main request. In fact, D52 first explains (see section 1, "Introduction") the advantages of introducing a precooling step in the method for argon liquefaction. Thereafter, in section 2.1, it discloses with reference to figure 2 the configuration of the test stand used for the experiments, this including a precooler. According to D52 (fourth line under section 2.1), "*R404A was chosen as the refrigerant for the pre-cooler.*" Contrary to the appellant's view, nowhere does D52 disclose or suggest that the mixed refrigerant compositions M2 and M3 defined in the table in section 2.2 were used in the precooler, let alone to replace R404A. As pointed out by the respondent, these compositions M2 and M3 were used in D52 for the main cooling step leading to argon liquefaction. This results from section 2.2 of D52 (see also figures 5 and 6) showing the results in terms of energy efficiency and liquid argon yield as obtained *inter alia* with compositions M2 and M3. This is further confirmed by the "Discussion" section of D52 which discloses that the experiments were carried out with an argon pressure of 20 bar. As argued by the respondent and not contested by the appellant, at such a pressure the boiling point of argon is considerably higher than the 87 K referred to by the appellant; therefore, the lowest temperatures around 100 K shown in figure 4 of D52 achieved with compositions M2 and M3, which were referred to by the appellant, demonstrate the ability of these mixtures to liquefy argon and do not refer, as argued by the appellant, to the precooling step. In fact, as submitted by the respondent, D52 does not disclose any temperature being achieved with the precooling step. Therefore, the board concurs with the respondent's view that, even having consulted D52, the skilled person would at most have been prompted to use R404A as the refrigerant for the precooler in the method of D64, and not compositions M2 or M3. However, as undisputed by the appellant, the subject-matter of claim 1 of the main request would not have been arrived at if R404A were used.

7.4.3 As regards the simulations provided by the appellant (statement of grounds of appeal, pages 7 to 13) and comparing the refrigeration performance of mixtures M2 and M3 for argon and hydrogen liquefaction, these simulations would have been carried out by the skilled person only with hindsight knowledge of the claimed invention. In fact, as set out above, D52 does not contain any indication that compositions M2 and M3 could be used for precooling, let alone for precooling hydrogen. Therefore, these simulations are merely the result of an impermissible *ex post facto* approach.

7.5 For these reasons, the board concluded that the subject-matter of claim 1 of the main request involves an inventive step within the meaning of Article 56 EPC.

Conclusion

8. None of the appellant's objections against the main request is convincing.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

U. Bultmann M. O. Müller

Decision electronically authenticated