December 20, 2023

California Air Resources Board
Hydrofluorocarbon Reduction
1001 I Street, Sacramento, California 95814
HFCReduction@arb.ca.gov

VIA EMAIL

Re: Variance Application Submission and Trade Secret Protection

To Whom It May Concern:

SMC Corporation of America (SMC) is pleased to resubmit this variance request to the California Air Resources Board (CARB) regarding Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-conditioning, and Other End-Uses.

SMC is a global manufacturer headquartered in Tokyo, Japan, with significant operations in the United States, Europe, and China. SMC manufacturers chillers and other temperature control equipment to provide thermal stability for applications in industrial and applied sciences, such as laser cutting, welding, marking, and plastic injection molding. SMC equipment also is used in a range of lab science and analytical applications, such as mass spectrometry, gas chromatography, MRIs, CT scanners, and radiation therapy machines and other medical equipment.

SMC's equipment is highly customized, with 110 models of its thermo-chillers for general industrial applications and 80 models of its thermo-chillers for semiconductor manufacturing processes. SMC also manufactures 98 models of air dryers. To date, as refrigerants, SMC has relied upon R-134a, R-404A, R-407C, and R-410A.

SMC is strongly committed to the global phase down of HFCs pursuant to the Kigali Amendment to the Montreal Protocol, the American Innovation and Manufacturing Act of 2020 in the United States, and the laws and regulations in the State of California.

As SMC works diligently to transition to lower GWP refrigerants, SMC seeks a temporary variance for the reasons set forth in the enclosed application.

As part of the information submitted to CARB for this variance, SMC is asserting that the specified items in the enclosed application and the attachments listed below are proprietary and constitute trade secrets within the meaning of California Government Code Section 7924.510, which states that "trade secrets are not public records ... ."

A "trade secret" is defined under Section 7924.510(f) as including any "formula, plan, pattern, process, tool, mechanism, compound procedure, production data, or compilation of information which is not patented, which is known only to certain individuals within a commercial concern who are using it to fabricate, produce, or compound an article of trade or a service having commercial value and which gives its user an opportunity to obtain a business advantage over competitors who do not know or use it."

The information contained in these documents, including equipment and emissions data is carefully guarded information about SMC products that, if known to the public, would create a business advantage for SMC competitors and be highly damaging commercially to SMC.

We also will note that the equipment and emissions data are presented here for purposes of calculating emissions and, per Section 7924.510(d)[1] and, for purposes of Question P, Section 7924.510(e)[2], thus remain under trade secret protection.

Accordingly, SMC is submitting the specified items in the enclosed application and the attachments to CARB as trade secrets and respectfully requesting that they not be disclosed to the public or otherwise made available to the public:

- Responses to Questions I, J, L, N, P, and Q (application)
- SMC Variance Refrigerant Transition Plan Overview (attachment)
- SMC Variance Component Unavailability (attachment)

Thank you for your time and attention to these matters. Please do not hesitate to contact me directly if I can provide any further information or answer any additional questions.

Sincerely,

Taira Omiya
Design Engineering Manager
SMC Corporation
10100 SMC Boulevard
Noblesville, IN 46060
Tel. 317-688-0582 | Email. tomiya@smcusa.com

[1] Section 7924.510(d) of the California Government Code states: "Data used to calculate emission data are not emission data for the purposes of this subdivision and data that constitute trade secrets and that are used to calculate emission data are not public records."
[2] Section 7924.510(e) of the California Government Code states: "Data used to calculate the costs of obtaining emissions offsets are not public records."

VARIANCE APPLICATION TO THE CALIFORNIA AIR RESOURCES BOARD

Respectfully submitted by SMC Corporation for Industrial Process Refrigeration Chillers

December 20, 2023

REDACTED VERSION

317-688-0151Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Stationary Air-conditioning, and Other End-Uses.

Application for a Variance from the requirements of California Code of Regulations, Title 17, sections 95374 and 95375.

Application submitted via email to: HFCREDUCTION@ARB.CA.GOV

QUESTION A.

Name of applicant: SMC Corporation of America ("SMC")

Ownership status (e.g., parent, subsidiary): Subsidiary of SMC Corporation

Address: 10100 SMC Blvd, Noblesville, Indiana 46060

Telephone number: 317-688-0151

E-mail address: yyamada@smcusa.com

QUESTION B.

Please describe your business activity or product description:

SMC is a global manufacturer headquartered in Tokyo, Japan, with significant operations in the United States, Europe, and China.

SMC manufacturers industrial process refrigeration chillers and other temperature control equipment to provide thermal stability for applications in industrial and applied sciences, such as laser cutting, welding, marking, and plastic injection molding. SMC equipment also is used in a range of lab science and analytical applications, such as mass spectrometry, gas

chromatography, MRIs, CT scanners, and radiation therapy machines and other medical equipment.

SMC's equipment is highly customized, with 110 models of its thermo-chillers for general industrial applications and 80 models of its thermo-chillers for semiconductor manufacturing processes. SMC also manufactures 98 models of air dryers. To date, as refrigerants, SMC has relied upon R-134a, R-404A, R-407C, and R-410A.

QUESTION C.

Please describe your relationship to the product:

SMC is the manufacturer of its products.

QUESTION D.

List the specific section(s) of the regulation from which a variance is being requested:

Section 95374(c) of Subarticle 5 of California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4

QUESITON E.

Provide an explanation and description of the reasons for seeking a variance:

SMC has been working diligently to identify and transition to low GWP refrigerants in its Industrial Process Refrigeration Chillers (IPR Chillers). See attached description of SMC's multi-phase transition plan. However, SMC has encountered both regulatory and practical barriers to completing its transition prior to January 1, 2024, and is concerned its customers, including U.S. semiconductor manufacturers, will face disruptions in equipment availability as a result.

SMC started evaluating substitute refrigerants in 2020. In evaluating substitute refrigerants, SMC's two biggest concerns were regulatory approval (for safety) and availability of components. SMC considered a wide range of substitutes, but, as discussed more fully bellow, ultimately narrowed the list to the following refrigerants: R-1234yf, R-32, and R-454C.

Regulatory Concerns

From a safety standpoint, the U.S. Environmental Protection Agency (EPA) has proposed approving, subject to use conditions, R-1234yf, R-32, and R-454C under its Significant New Alternatives Policy (SNAP). 88 Fed. Reg. 33722 (May 24, 2023) (SNAP 26). SMC is responsible for

the R-32 submission under SNAP for IPR Chillers. However, the SNAP 26 rule is not yet final as of the date of this application. Lack of final regulatory approval under SNAP, even where such approval is likely, presents significant commercial and regulatory risk for SMC and its customers. For this alone, SMC believes a variance is appropriate until SNAP 26 is finalized.

The release of the final SNAP 26 rule would resolve a major regulatory barrier, but only if any use conditions required for approved substitutes in IPR Chillers – which are expected for all A2L substitutes – are attainable based on SMC's current equipment designs.

Most use conditions confirm to applicable ASHRAE or UL standards, but sometimes refer to older editions in lieu of new editions released during the rulemaking process for a given SNAP rule. This can interfere with the recertification process for SMC equipment, since typically only the most recent version of an applicable standard is acceptable. Where an EPA SNAP rule refers to an older version, this conflict must be resolved by EPA via further rulemaking or guidance before the regulatory risk facing SMC may be considered resolved.

Moreover, even where such regulatory risk is totally resolved, component availability remains a significant and insurmountable barrier. If components are not available, SMC cannot manufacture new equipment utilizing substitute refrigerants. This remains an ongoing challenge for SMC, as described here in this application.

Component Availability

From a component availability standpoint, none of SMC's component suppliers currently manufacture components specifically designed for IPR Chillers that can accommodate substitutes such as R-1234yf, R-32, and R-454C. Components for other types of equipment do exist for these substitutes, but they are incompatible with IPR Chillers. SMC estimates that compatible components will not be available potentially until early 2025.

SMC has enclosed with this application a presentation documenting the challenges it is facing to procure components for substitute refrigerants. See attached SMC Variance Component Unavailability (contains information protected as trade secrets).

If components for substitute refrigerants compatible with SMC's IPR Chillers were available, SMC would have procured such components and sought to use them in its equipment (pending regulatory approval under SNAP). Such components remain largely unavailable, posing unavoidable delays in SMC's transition to substitute refrigerants.

It should be noted that SMC designs highly specialized IPR Chillers for specific uses in precision manufacturing. SMC has 120 models of IPR Chillers and customizes many of them further to meet exacting customer requirements. These are not "mass market" or "off the shelf" products. They are entirely distinct from chillers for comfort cooling and even many other IPR Chiller

devices, with drastic differences in design, function, and use. Therefore, a variance for SMC's IPR Chillers poses no risk of setting a precedent that would benefit other types of equipment unnecessarily.

As indicated in the attachment SMC Variance Component Unavailability (contains information protected as trade secrets), the supply chain for SMC's IPR Chillers is as bespoke as its products, and retooling such a supply chain takes considerably more time than for equipment types that cater to a broader and much more generalized consumer market.

Conclusion

Accordingly, SMC considers it impossible to transition to R-1234yf, R-32, or R-454C until ***January 1, 2025***, and respectfully requests a variance until that date. SMC respectfully notes that this date still is one year earlier than the transition date for IPR Chillers recently finalized by EPA in the so-called Technology Transitions Final Rule, at 88 Fed. Reg. 73098 (Oct. 24, 2023).

QUESTION F.

Identify what type of variance is being requested:

☒ ***Impossibility*** (the Applicant exercised best efforts but still was unable to comply with the regulatory requirements of the regulation for reasons beyond his or her control despite exercising foresight to prevent the noncompliance.)

QUESTION G.

If seeking an Impossibility variance, please provide clear and convincing evidence demonstrating how all of the following Impossibility variance criteria have been met:

In addition to the following discussion, please refer to SMC's answer to Question E, above.

1. A lower risk substitute is not currently or potentially available.

As described above, EPA has not yet issued final approval under SNAP for R-1234yf, R-32, and R-454C for IPR Chillers. Although approval is likely, lack of such approval presents an unacceptable level of safety and regulatory risk for SMC and its customers, particularly those in the semiconductor industry engaged in precision manufacturing. Moreover, also as described above, components specifically made for IPR Chillers that are compatible with R-1234yf, R-32, and R-454C are not available for use by SMC in manufacturing new IPR Chillers.

In addition to R-1234yf, R-32, and R-454C, SMC did evaluate other potential substitute refrigerants.[1] But none of these refrigerants satisfy SMC's basic criteria for regulatory approval (for safety) and component availability.

In particular, many of these other substitute refrigerants are flammable or toxic and cannot be used in enclosed spaces and other indoor areas with limited ventilation, such as those used in semiconductor manufacturing and other precision industrial processes. Consider the following:

- Propylene (R-1270), Butane (R-600), Propane (R-290) are classified as A3 for flammability.
- Ammonia is classified as B2L for flammability and toxicity and no components are available for IPR Chillers.
- Carbon dioxide and nitrogen require significant increases in pressure, resulting in significant increases in energy consumption and specialty materials that render them substantially worse from a climate mitigation perspective.
- R-450A and R-513A lack components compatible with IPR Chillers.

To elaborate further regarding lack of component availability, SMC's IPR Chillers are available in 120 models with cooling capacities ranging from 1 kW to 40 kW and are characterized by their compact exterior. Compressors compatible with new refrigerants for each cooling capacity that can fit in such a compact enclosure require entirely new manufacturing lines to produce, necessitating a transition at the supplier level before IPR Chiller manufacturers can similarly transition. Existing components for substitute refrigerants, such as for use in other types of air conditioning applications, are incompatible with IPR Chillers due to design and use constraints by SMC customers, such as those in the semiconductor industry, which prohibit changes to external dimensions of equipment.

SMC wishes to emphasize that its place in the market is distinct, if not unique. There is no "mass market" for the many kinds of IPR Chillers made by SMC. There are no cognizable competitors in many of these niche markets, which are characterized by customer relationships that date to

[1] *See* Phasedown of Hydrofluorocarbons: Restrictions on the Use of Certain Hydrofluorocarbons Under Subsection (i) the American Innovation and Manufacturing Act of 2020, 87 Fed. Reg. 76738, 76787 ("For its consideration of the availability of substitutes under subsection (i)(4)(B), EPA identified substitutes that are available in place of the substances that EPA is proposing to restrict. These include R–717 (GWP 0), R–744 (GWP 1), R–1270 (GWP 2), R–290 (GWP 3), R–600 (GWP 4), R–450A (GWP 601), and R–513A (GWP 630). Chillers for IPR that use lower-GWP substitutes are currently available in both U.S. and international markets. In the United States, chillers for IPR using R–717, R– 290, R–744, and R–513A are all available on the market. Internationally, equipment using R–1270 is available as well.").

the early 1980s and involve bespoke manufacturing processes and specifications that require extremely high levels of precision, such as for semiconductors. This means there is no market for compatible components for SMC's IPR Chillers until SMC requests them. SMC has made such requests, but, as explained more fully above and in the attached documents, component manufacturers have indicated that components for substitute refrigerants are not yet available for SMC to manufacture new IRP Chillers. See attached SMC Variance Component Unavailability (contains information protected as trade secrets).

Moreover, changes in refrigerant type directly affect the performance of the semiconductor process and require changes in the process recipe. This requires re-verification of the process, which requires re-verification by SMC and its suppliers. This can require over 1,000 re-verifications, which can take several years to complete, along with a lengthy certification process by UL for 60335-2-89 and 61010, which also EPA has proposed as use conditions in SNAP 26, which remains not yet finalized. This presents yet another potential problem, if either UL standard is updated while EPA approval requires compliance with an earlier edition of the UL standard. In other words: SMC believes it is moving with unprecedented speed just to have completed its transition by ***January 1, 2025***, but cannot do so earlier under any circumstances.

SMC believes granting a variance for this period of time will not result in any new or additional harm to public health or the environment, and SMC will take such steps as may be necessary to offset in CO_2-equivalent terms the additional high GWP HFC substances it will use over that time period (notwithstanding that most of these substances will not be emitted, but instead recovered and reclaimed or destroyed at equipment end-of-life).

2. An exemption will not increase the overall risk to human health or the environment.

As described above, the additional use of high GWP substances during the time requested in this variance will be minimal and, in any event, will not be emitted into the atmosphere, as SMC will ensure it is recovered and either reclaimed or destroyed at equipment end-of-life.

SMC's refrigerant-related products R134a, R410A, and R407C do not increase the risk to human health compared to alternative refrigerants. This is because, while higher in GWP, these refrigerants produce superior thermal efficiency, resulting in lower overall carbon emissions.

In addition, these refrigerants are in the less toxic Class A category and pose no increased risk to human health. All of SMC's IPR Chillers are assembled at the factory, with no on-site assembly or refrigerant encapsulation, thereby eliminating emissions at installation.

SMC equipment also is subjected to stress analysis based on transport vibration and copper tube strain measurements, so on-site refrigerant leakage failure is very low (0.3%) and refrigerant circuits are taken back for repair (refrigerant is recovered and maintained).

Refrigerant recovery at the time of disposal to the customer is also instructed in the manual, so the risk of releasing refrigerant into the atmosphere is considered very low.

Notwithstanding the foregoing, SMC will offset in CO_2-equivalent terms an amount equal to the additional substances used during the variance period through the purchase of carbon offsets from a reputable provider.

3. The Applicant has used best efforts to anticipate and address the impossibility and any potential noncompliance.

SMC has been preparing for a transition to lower GWP substitutes since 2020, but, in addition to the reasons described above, the complexity of its highly specialized equipment, particularly for use in the semiconductor manufacturing industry, requires additional time to complete this transition.

QUESTION H.

If seeking a Force Majeure Event variance please provide clear and convincing evidence demonstrating how all of the following Force Majeure variance criteria has been met:

SMC Corporation is not seeking a Force Majeure Event variance.

QUESTION I.

Please attach supporting documentation for attributing noncompliance to Impossibility or a Force Majeure Event. Supporting documentation must be written in English. Please list the supporting documentation that is attached to this application.

The attachments listed below contain confidential information protected as a trade secret under the California Public Records Act and may not be disclosed to the public pursuant to section 7924.510 of the California Government Code.

- 03 – SMC Variance Refrigerant Transition Plan Overview
- 04 – SMC Variance Component Unavailability

The following attachment does not contain confidential information:

- 05 – SMC Variance Product Data MTBF for SMC's IPR Chillers

QUESTION J.

Provide a description of all efforts made to timely fulfill the requirements of the section(s) from which a variance is being requested.

The response to this question contains confidential information protected as a trade secret under the California Public Records Act and may not be disclosed to the public pursuant to section 7924.510 of the California Government Code.

[redacted]

QUESTION K.

Please provide the length of the variance requested as well as the earliest date when compliance will be achieved.

SMC respectfully requests a variance until ***January 1, 2025***.

QUESTION L.

Provide a compliance plan which describes in detail how, if a variance is granted, compliance will be achieved as expeditiously as possible including all of the following:

(i) The method by which compliance will be achieved

SMC will transition to refrigerants with GWPs below 700.

(ii) Milestone dates

The response to this question contains confidential information protected as a trade secret under the California Public Records Act and may not be disclosed to the public pursuant to section 7924.510 of the California Government Code.

[redacted]

(iii) Milestone achievements

The response to this question contains confidential information protected as a trade secret under the California Public Records Act and may not be disclosed to the public pursuant to section 7924.510 of the California Government Code.

[redacted]

QUESTION M.

Provide a description of the damage or harm that will result to the Applicant from immediate compliance with the regulatory requirements, including if compliance would result in an extraordinary economic hardship, such as closure of the entire facility or loss of a large portion or the revenue:

SMC is developing 120 low-GWP chiller models, but if replacements cannot be supplied, a total of about 860 units/year, or about $18.2 million, are expected to be lost in its California market.

SMC believes its customers will be unable to replace existing equipment or purchase new equipment in those product lines where SMC has not yet completed its transition to lower GWP substitutes.

The economic impacts will vary from customer to customer, but in many cases SMC customers are U.S. semiconductor manufacturers seeking to expand operations in response to the CHIPS and Science Act and Inflation Reduction Act.

Since the company has supply contracts with semiconductor manufacturers and is obligated to supply semiconductors in a timely manner, any delay in supply could result in a breach of

contract. This could result in a loss of market share, and in the worst case, a claim for compensation for breach of contract could be filed.

Furthermore, manufacturers of medical equipment such as MRIs, CT scanners, radiation therapy equipment, and laser therapy equipment are also SMC customers, and FDA certification renewal is mandatory when the SMC chiller component is changed, resulting in significant costs and delays.

QUESTION N.

If applying for an Impossibility variance please provide quantification of current Greenhouse Gas (GHG) emissions resulting from normal business-as-usual operations as it directly relates to the continued use of any substance in end-uses listed in Table 1, section 95374 (a); Table 2, section 95374 (b); Table 3, section 95374 (c); or Table 4, section 95374 (d). This includes quantification of the direct GHG emissions resulting from refrigerant leaks or HFC emissions and indirect GHG emissions resulting from energy use (where applicable), with all calculations, based on the average lifetime of the equipment or product that will continue to use prohibited substances. Applicant must include all calculations used to calculate GHG emissions estimates, including emission factors (i.e., charge size as defined in section 95373, leak rate as defined in 40 C.F.R. Part 82.152, and refrigerant used over the average lifetime of the equipment, system, or product).

The response to this question contains confidential information protected as a trade secret under the California Public Records Act and may not be disclosed to the public pursuant to section 7924.510 of the California Government Code.

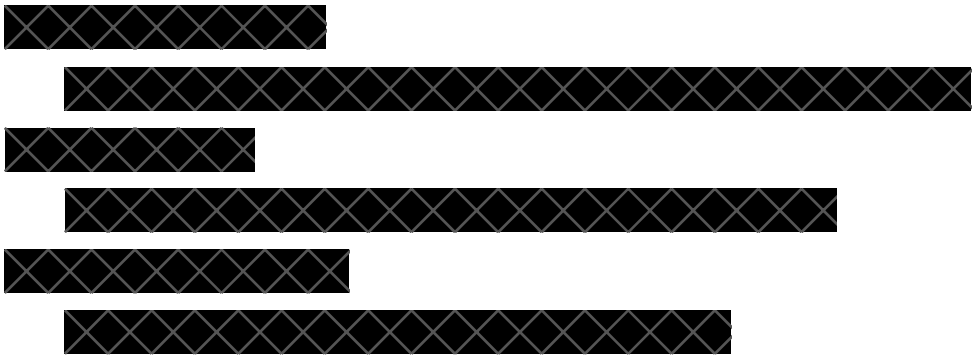
TOTAL: 2,343.6 MTCO2e of carbon dioxide-equivalent

The refrigerant in SMC equipment is not emitted and is recovered at end of life.

In accordance with the criteria provided under Question N, SMC offers the following information regarding its GHG emissions:

The average annual leak rate from SMC IPR Chillers is 0.3%, and the average loss rate at end-of-life is 98.5%, and the average lifetime is 10 years. Note this average loss rate at end-of-life is a "worst case" scenario assumption, used here to ensure maximal environmental protection.

[redacted]



5. Total GHG emissions
    - 2343.6 MTCO2e

In addition, if any low-GWP alternatives are available and are sold prior to January 1, 2024, the corresponding CO2e amount shall be deducted from these totals based on the number of such sales.

QUESTION O.

Provide a description of any negative impacts to human health or the environment that may result from the granting of a variance.

SMC does not believe any negative impacts to human health or the environment will occur, given the minimal likelihood of any emissions and, even in such a case, the negligible quantity of such emissions.

QUESTION P.

Provide a mitigation plan that demonstrates how you will reduce excess GHG emissions to a level equal to or below what would have been emitted had you been in compliance and how you will mitigate any negative impacts to human health or the environment. You must include all calculations used to calculate GHG emission estimates including emission factors (i.e., charge size as defined in section 95373, leak rate as defined in 40 C.F.R. Part 82.152, and refrigerant used over the average lifetime of the equipment, system, or product). This may include an analysis of prohibited substances, efforts to reduce leaks or venting of prohibited substances, and options to recycle or destroy high-Global Warming Potential refrigerants.

The response to this question contains confidential information protected as a trade secret under the California Public Records Act and may not be disclosed to the public pursuant to section 7924.510 of the California Government Code.

SMC Corporation will purchase a quantity of carbon offsets equal to 2,220 metric tons of carbon dioxide-equivalent from a reputable offset provider upon granting of the variance. [redacted]

The offset amount shown above is the total emissions for Question N minus the GHG emissions that would be emitted even if all IPR Chillers sold in California were converted to R454C refrigerant in compliance with the CARB.

Details of the GHG emission to be deducted will be as follows:

[redacted]

5. Total GHG emissions
    - 127.9 MTCO2e
6. Excessive GHG emissions
    - 2,343.6 MTCO2e-127.9 MTCO2e = 2,215.7 MTCO2e

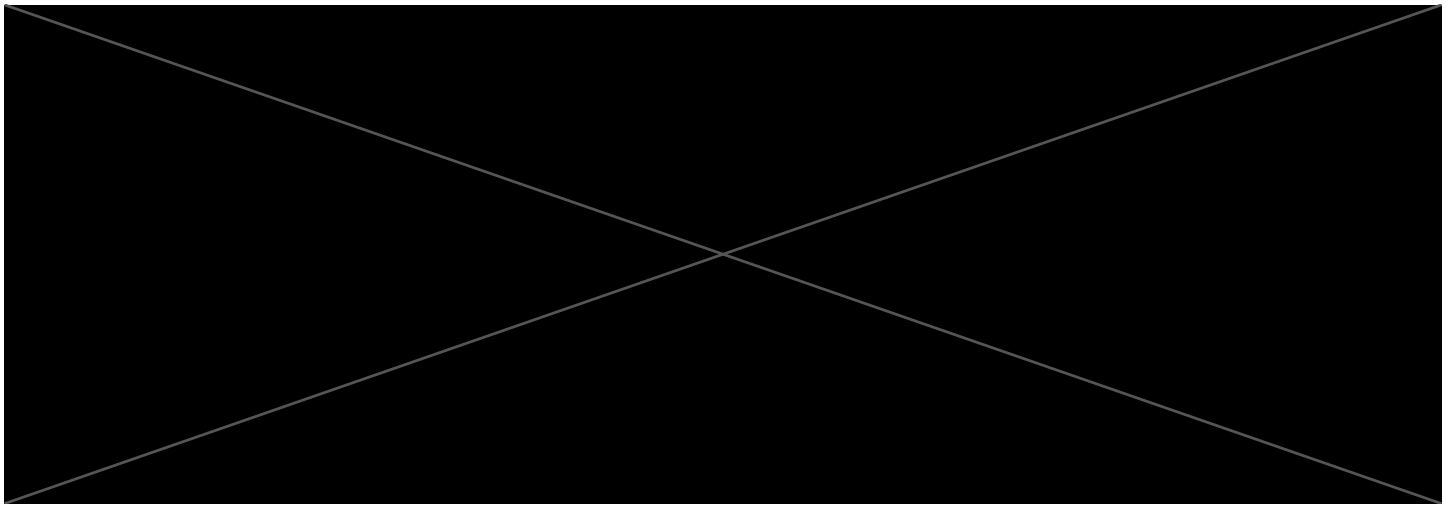
Upon being granted a variance, SMC will engage a reputable provider of carbon offsets under Verra or a comparable standard and purchase offsets equal to this total.

QUESTION Q.

Provide a detailed explanation of efforts that may be implemented to curtail noncompliance in lieu of obtaining a variance

The response to this question contains confidential information protected as a trade secret under the California Public Records Act and may not be disclosed to the public pursuant to section 7924.510 of the California Government Code.

SMC does not believe there are adequate measures at its disposal to "curtail noncompliance" in lieu of obtaining a variance.



By signing below, you (the Applicant) certify under penalty of perjury that you are a Responsible Official with full authority to submit the application and implement any provision of an Executive Order, and that all information provided is true and accurate to the best of your knowledge, after conducting due diligence. (Applications without this certification will be automatically denied.)

December 22, 2023

_____ _____

Taira Omiya, Design Engineering Manager — Date

SMC Corporation of America

Doc. No	DOC1005162
1st Edition	3rd Jun, 2022.

Product Data
(MTBF)

Product Name

Thermo Chiller

Model / Series / Part No.

HRLE series

Prepared by: Product Development Division 6

Approved	Checked	Prepared
DIV.6 M.Watanabe Jun.6,2022	DIV.6 K.Fujii Jun.3,2022	DIV.6 M.Takahashi Jun.3,2022

SMC CORPORATION

I. MTBF(Mean Time Between Failure)

1. Target MTBF

1.1. How to calculate target MTBF

Target failure rate of equipment to form Thermo-chiller(HRLE series) shall be assumed and calculated based on values from reliability test result, values submitted by parts manufacturer, result obtained from operating field.

Target failure rate $\lambda = \lambda 1 + \lambda 2 + \lambda 3 + \lambda 4 + \cdots\cdots + \lambda n$

Target MTBF $= 1/\lambda$

Target failure rate of $\lambda 1, \lambda 2, \lambda 3, \lambda 4, \cdots\cdots, \lambda n$: n pcs. of component

Please be noted that values of this MTBF and failure rate are values when the Thermo-chiller receives periodic maintenance according to its maintenance standard. They do not guarantee the reliability of the thermo-chiller.

1.2. Calculation result of target MTBF

Table 1 Target MTBF and target failure rate(HRLE***-A-**-*)

Item		Applicable models HRLE***-A-**-*		Remarks
Number	Block	Target MTBF (h)	Failure rate (ppm)	
1	Circulating fluid circuit	153,400	6.52	Refer to page 2 (Table 3)
2	Refrigerant circuit	164,700	6.07	Refer to page 2 (Table 4)
3	Facility water circuit	—	—	—
4	Electric circuit	1,087,000	0.92	Refer to page 3 (Table 6)
Total		79,900	12.51	—

Table 2 Target MTBF and target failure rate(HRLE***-W-**-*)

Item		Applicable models HRLE***-W-**-*		Remarks
Number	Block	Target MTBF (h)	Failure rate (ppm)	
1	Circulating fluid circuit	153,400	6.52	Refer to page 2 (Table 3)
2	Refrigerant circuit	197,200	5.07	Refer to page 2 (Table 4)
3	Facility water circuit	8,333,300	0.12	Refer to page 3 (Table 5)
4	Electric circuit	1,087,000	0.92	Refer to page 3 (Table 6)
Total		86,000	11.63	—

Table 3 Target failure rate of component(Circulating fluid circuit Block)

Number	Description of component	Target Failure rate (ppm)	Failure Mode
A1	Tank	0.01	Crack, Leakage, Stain, Foreign matter
A2	Level switch	0.10	Crack, Malfunction
A3	Pump	5.00	Corroded fluid, Locked rotor, Abrasion, Current leakage, Insulation failure
A4	Temperature sensor (for CH1 discharge)	0.10	Short-circuit, Broken wire, Opened wire
A5	Temperature sensor (for return port)	0.10	Short-circuit, Broken wire, Opened wire
A6	Temperature sensor (for CH2 discharge)	0.10	Short-circuit, Broken wire, Opened wire
A7	Pressure sensor	0.10	Short-circuit, Broken wire, Opened wire
A8	Hose and fitting	0.01	Leakage, Deformation
A9	Heat exchanger (CH1)	0.50	Freezing, Clogging, Stain
A10	Heat exchanger (CH2)	0.50	Clogging, Stain
Block as a whole (Total)		6.52	

Table 4 Target failure rate of component(Refrigerant circuit Block)

Number	Description of component	Target Failure rate (ppm)	Failure Mode
B1	Copper tube	0.01	Leakage
B2	Electronic Expansion Valve (for CH1 cooling)	0.15	Locked
B3	Electronic Expansion Valve (for CH1 heating)	0.15	Locked
B4	Electronic Expansion Valve (for CH2 heating)	0.15	Locked
B5	Pressure sensor (high pressure side)	0.10	Short-circuit, Broken wire, Opened wire
B6	Pressure sensor (low pressure side)	0.10	Short-circuit, Broken wire, Opened wire
B7	Thermistor sensor	0.10	Short-circuit, Broken wire, Opened wire
B8	Pressure switch	1.00	Locked, Operating failure
B9	Refrigerant compressor	3.00	Abnormal vibration, Locked rotor, Current leakage, Dew condensation, Dew icing
B10	Air-cooled condenser	0.01	Clogging
B11	Fan motor (for air-cooled type)	1.00	Locked rotor, Insulation failure
B12	Refrigerant filter dryer	0.10	Clogging
B13	Heat exchanger (CH1)	0.10	Freezing, Clogging
B14	Heat exchanger (CH2)	0.10	Clogging
Block as a whole (Total)		6.07	

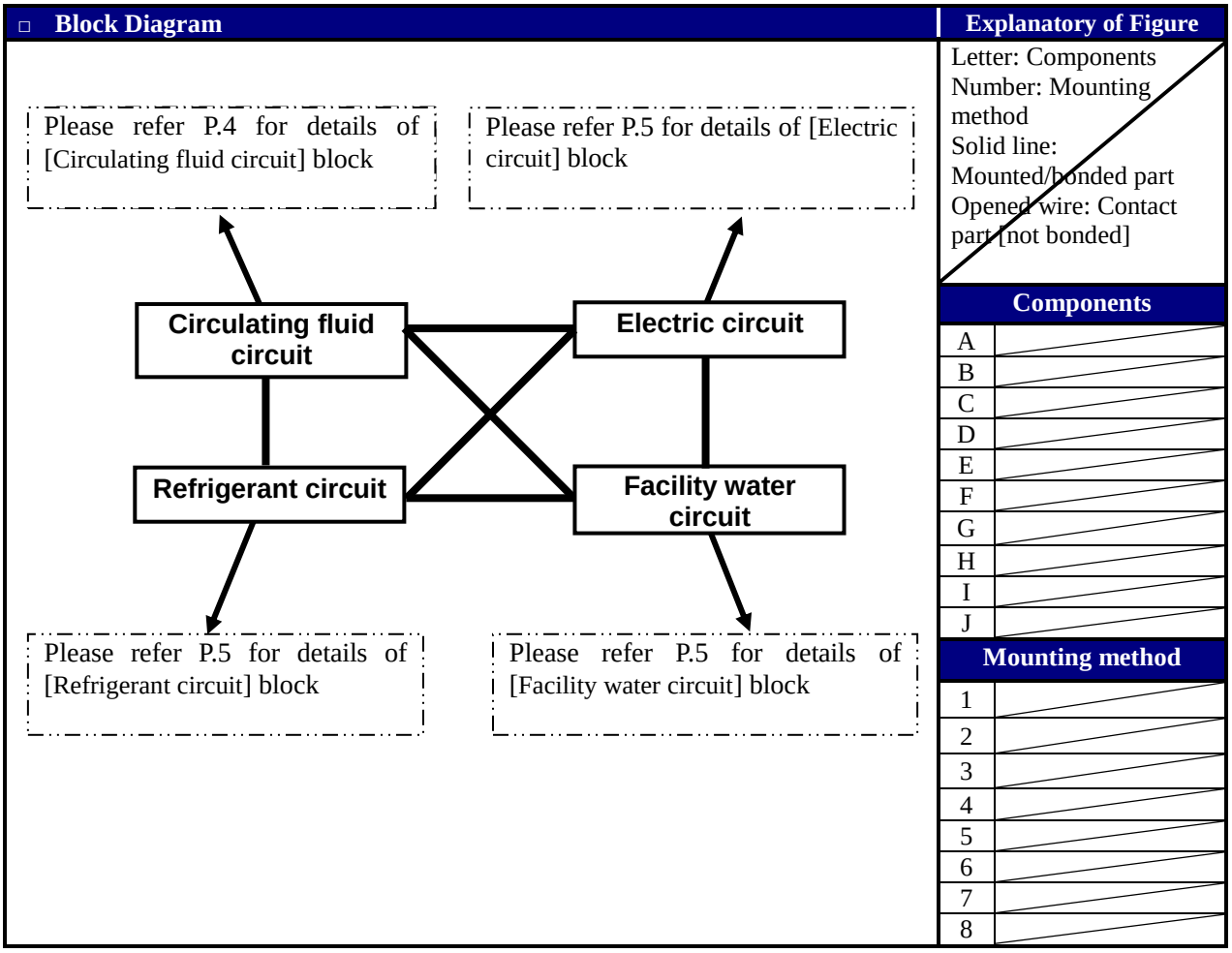
Table 5 Target failure rate of component(Facility water circuit Block)

Number	Description of component	Target Failure rate (ppm)	Failure Mode
C1	Water-cooled condenser	0.10	Clogging
C2	Water regulator	0.01	Abrasion of valve
C3	Piping and fitting	0.01	Leakage
Block as a whole (Total)		0.12	

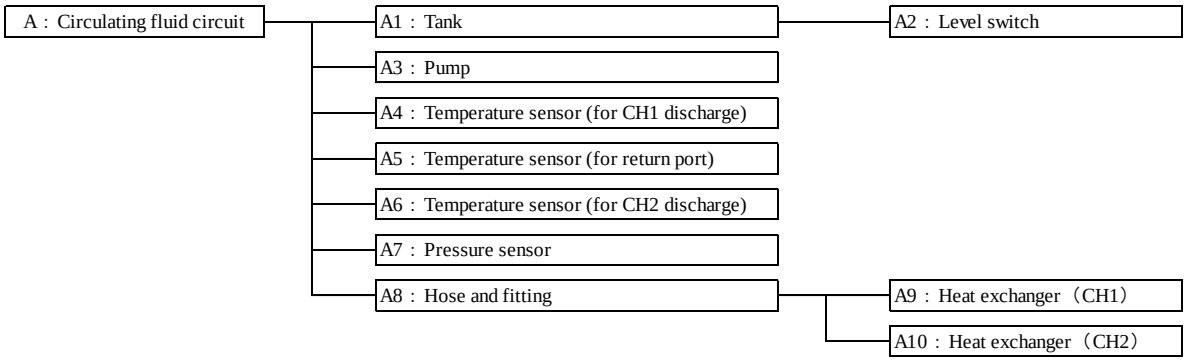
Table 6 Target failure rate of component(Electric circuit Block)

Number	Description of component	Target Failure rate (ppm)	Failure Mode
D1	Main breaker	0.05	Operating failure, Abnormal heating
D2	Noise filter	0.01	Insulation failure, Abnormal heating
D3	Magnetic contactor	0.50	Operating failure, Abnormal heating
D4	Circuit protector	0.01	Operating failure, Abnormal heating
D5	DC power supply	0.10	Abnormal output voltage
D6	Power switch	0.01	Operating failure
D7	Board (controller)	0.01	Operating failure
D8	Board (for display)	0.01	Operating failure
D9	Inverter (for refrigerant compressor)	0.10	Operating failure, Abnormal heating
D10	DC reactor (for refrigerant compressor)	0.01	Insulation failure, Abnormal heating
D11	Inverter (for pump)	0.10	Operating failure, Abnormal heating
D12	Program	0.01	Control failure
Block as a whole (Total)		0.92	

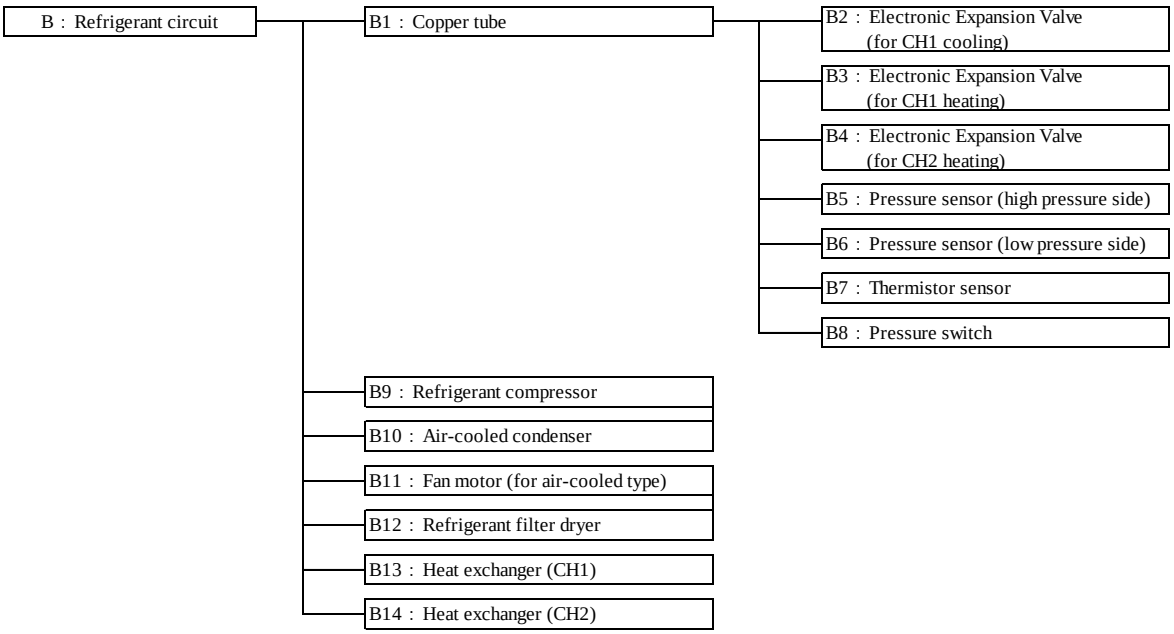
1.3. Block Diagram



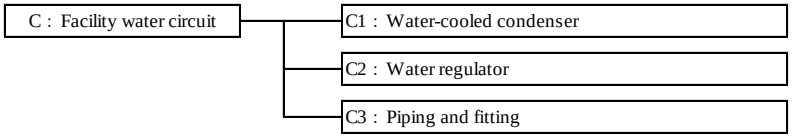
1.4. Circulating fluid circuit Block



1.5. Refrigerant circuit Block



1.6. Facility water circuit Block



1.7. Electric circuit Block