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Emissions of Mercury during GAC Malfunction
Green Bay Metropolitan Sewerage District (NEW Water)
November 21, 2019 – February 13, 2020

The purpose of this report is to provide a summary of emissions of mercury while incinerating sewage sludge without use of the granulated activated carbon (GAC) adsorber on a limited basis from November 21, 2019 until February 13, 2020. The GAC was rendered inoperable after a high temperature condition caused extensive internal damage to the unit.

GBMSD is subject to two emission limits for mercury under its air operation permit. The first is a mass limit of 3.2 kg (7.1 pounds) per 24-hour period, established under the National Emission Standard for Mercury (40 CFR 61, Subpart E). The second is a concentration limit of 0.0010 milligrams per dry standard cubic meter (mg/dscm), corrected to 7% oxygen, established under the Standards of Performance for New Stationary Sources: Sewage Sludge Incineration Units (40 CFR 60, Subpart LLLL).

Mercury Emissions – Mass

GBMSD demonstrates compliance with the mass limit for mercury of 3.2 kg (7.1 pounds) per 24-hour period in two ways; by conducting emissions testing and by calculating emissions using sludge feed and mercury content of sludge.

Emissions testing

Emissions testing for mercury while incinerating sewage sludge without the GAC was conducted on December 12, 2019. GBMSD's other air pollution control processes, including combustion temperature control, wet scrubber, and wet electrostatic precipitator, were operating at all times when incineration took place, including during emissions testing. EPA Method 29 was used to measure emissions of mercury. Results showed that mass emissions of mercury without the GAC were 0.0155 pounds per 24-hour period, which is in compliance with the 7.1 pounds per 24-hour limit.

Emissions calculation

To estimate emissions on a mass basis while incinerating sewage sludge without use of the GAC, Wisconsin Department of Natural Resources (WDNR) requested that GBMSD analyze a weekly sewage sludge sample for mercury content and use that value, along with the sludge charging rate to the incinerator, as inputs for the equation in Operating Permit 405004600-P30, Section F.5 (b)(2)(d).

$$E_{Hg} = \frac{MQF_{sm(avg)}}{1000}$$

where:
E_{Hg}=Mercury emissions, g/day.
M=Mercury concentration of sludge on a dry solids basis, µg/g.
Q=Sludge charging rate, kg/day.
F_{sm}=Weight fraction of solids in the collected sludge after mixing.
1000=Conversion factor, kg µg/g^2.

Beginning on December 12, 2019 a grab sample of sewage sludge was taken each week until the GAC was returned to service on February 13, 2020. The mercury content of each weekly sample was applied when calculating mercury emissions from all incineration that took place Sunday through Saturday of the week during which the sample was taken. For the weeks before weekly sampling commenced, the highest mercury result that occurred during the GAC outage was applied (0.62 ug/g on January 15, 2020).

Results are summarized in Table 1. Using the equation above, daily emissions of mercury ranged from 0.004 pounds per day to 0.054 pounds per day, with an average of 0.028 pounds per day. The applied equation assumes that no removal of mercury occurred; however, please note that even without the GAC, GBMSD's emissions of mercury were controlled by a wet scrubber, a wet electrostatic precipitator, and maintenance of allowable combustion temperature whenever incineration of sewage sludge occurred. GBMSD demonstrates compliance with its permitted limit for mercury mass emissions.

Table 1 GBMSD mercury mass emissions - November 21, 2019 through February 12, 2020

Date	*M* Mercury Concentration of Sludge (ug/g)[1,2]	*Q* Sludge Charging Rate (wet kg/day)	F_{sm} Weight Fraction of Solids	*Conversion Factor (kg ug/g²)*	E_{hg} Mercury emissions (g/day)[3]	Mercury Emissions (lb/day)	Mercury Emissions Limit (lb/day)
11/21/2019	0.62	38,031	0.375	1000	8.8	**0.019**	7.1
11/22/2019	0.62	87,492	0.404	1000	22	**0.048**	7.1
11/23/2019				OFFLINE			
11/24/2019	0.62	68,764	0.356	1000	15	**0.033**	7.1
11/25/2019	0.62	105,340	0.354	1000	23	**0.051**	7.1
11/26/2019	0.62	93,487	0.42	1000	24	**0.054**	7.1
11/27/2019	0.62	55,281	0.376	1000	13	**0.028**	7.1
11/28/2019				OFFLINE			
11/29/2019	0.62	85,155	0.409	1000	22	**0.048**	7.1
11/30/2019	0.62	97,731	0.407	1000	25	**0.054**	7.1
12/01/2019	0.62	95,865	0.412	1000	24	**0.054**	7.1
12/02/2019	0.62	85,028	0.383	1000	20	**0.045**	7.1
12/03/2019				OFFLINE			
12/04/2019	0.62	40,629	0.35	1000	8.8	**0.019**	7.1
12/05/2019	0.62	43,047	0.387	1000	10	**0.023**	7.1
12/06/2019	0.62	39,509	0.411	1000	10	**0.022**	7.1
12/07/2019	0.62	100,316	0.373	1000	23	**0.051**	7.1
12/08/2019				OFFLINE			
12/09/2019				OFFLINE			
12/10/2019				OFFLINE			
12/11/2019	0.24	21,122	0.389	1000	2.0	**0.004**	7.1

Date	*M* Mercury Concentration of Sludge (ug/g)[1,2]	*Q* Sludge Charging Rate (wet kg/day)	F_{sm} Weight Fraction of Solids	*Conversion Factor (kg ug/g²)*	E_{hg} Mercury emissions (g/day)[3]	Mercury Emissions (lb/day)	Mercury Emissions Limit (lb/day)
12/12/2019	0.24	102,988	0.389	1000	9.6	**0.021**	7.1
12/13/2019	0.24	102,107	0.359	1000	8.8	**0.019**	7.1
12/14/2019				OFFLINE			
12/15/2019				OFFLINE			
12/16/2019				OFFLINE			
12/17/2019				OFFLINE			
12/18/2019				OFFLINE			
12/19/2019				OFFLINE			
12/20/2019	0.53	76,426	0.363	1000	15	**0.032**	7.1
12/21/2019	0.53	97,920	0.372	1000	19	**0.043**	7.1
12/22/2019				OFFLINE			
12/23/2019				OFFLINE			
12/24/2019				OFFLINE			
12/25/2019				OFFLINE			
12/26/2019	0.29	88,732	0.371	1000	9.6	**0.021**	7.1
12/27/2019	0.29	91,346	0.391	1000	10	**0.023**	7.1
12/28/2019	0.29	86,031	0.403	1000	10	**0.022**	7.1
12/29/2019				OFFLINE			
12/30/2019				OFFLINE			
12/31/2019				OFFLINE			
01/01/2020	0.38	91,327	0.384	1000	13	**0.029**	7.1
01/02/2020	0.38	40,160	0.398	1000	6.1	**0.013**	7.1
01/03/2020	0.38	24,257	0.381	1000	3.5	**0.008**	7.1
01/04/2020	0.38	102,711	0.381	1000	15	**0.033**	7.1
01/05/2020	0.23	105,290	0.334	1000	8.1	**0.018**	7.1
01/06/2020	0.23	47,576	0.385	1000	4.2	**0.009**	7.1
01/07/2020				OFFLINE			
01/08/2020				OFFLINE			
01/09/2020				OFFLINE			
01/10/2020	0.23	55,113	0.394	1000	5.0	**0.011**	7.1
01/11/2020	0.23	95,397	0.38	1000	8.3	**0.018**	7.1
01/12/2020	0.62	34,381	0.416	1000	8.9	**0.020**	7.1
01/13/2020				OFFLINE			
01/14/2020				OFFLINE			
01/15/2020				OFFLINE			
01/16/2020				OFFLINE			

Date	*M* Mercury Concentration of Sludge (ug/g)[1,2]	*Q* Sludge Charging Rate (wet kg/day)	F_{sm} Weight Fraction of Solids	*Conversion Factor (kg ug/g²)*	E_{hg} Mercury emissions (g/day)[3]	Mercury Emissions (lb/day)	Mercury Emissions Limit (lb/day)
01/17/2020	0.62	77,234	0.383	1000	18	**0.040**	7.1
01/18/2020	0.62	96,186	0.366	1000	22	**0.048**	7.1
01/19/2020				OFFLINE			
01/20/2020				OFFLINE			
01/21/2020				OFFLINE			
01/22/2020				OFFLINE			
01/23/2020				OFFLINE			
01/24/2020	0.21	40,333	0.396	1000	3.4	**0.007**	7.1
01/25/2020	0.21	80,789	0.4	1000	6.8	**0.015**	7.1
01/26/2020				OFFLINE			
01/27/2020				OFFLINE			
01/28/2020				OFFLINE			
01/29/2020				OFFLINE			
01/30/2020				OFFLINE			
01/31/2020	0.50	50,566	0.351	1000	8.9	**0.020**	7.1
02/01/2020	0.50	102,969	0.364	1000	19	**0.041**	7.1
02/02/2020				OFFLINE			
02/03/2020				OFFLINE			
02/04/2020				OFFLINE			
02/05/2020				OFFLINE			
02/06/2020				OFFLINE			
02/07/2020	0.21	78,882	0.4	1000	6.6	**0.015**	7.1
02/08/2020	0.21	86,331	0.383	1000	6.9	**0.015**	7.1
02/09/2020	0.18	30,887	0.388	1000	2.2	**0.005**	7.1
02/10/2020				OFFLINE			
02/11/2020				OFFLINE			
02/12/2020				OFFLINE			

Notes:

(1) Mercury content as measured during weekly grab samples of sewage sludge. Sludge result was applied during all incineration that took place during the week the sample was grabbed, Sunday through Saturday.

(2) Weekly sludge samples began the week of December 12, 2019. For incineration that occurred prior to that, the highest mercury result was applied (0.62 ug/g)

(3) Equation from Permit Section F.5(b)(2)(d)

Mercury Emissions – Concentration

Emissions testing was performed on December 12, 2019 to measure emissions of mercury while the incinerator combusted sewage sludge without use of the GAC. Results showed that emissions of mercury during emissions testing were 0.0220 mg/dscm, corrected to 7% oxygen, which exceeds the permit limit of 0.0010 mg/dscm, corrected to 7% oxygen. The test report was submitted to US EPA and WDNR on January 24, 2020. Results from emissions testing were summarized and discussed in a cover letter and supplemental memo that accompanied the emissions test report. (The cover letter and supplemental memo can be found in Appendix 1 to this letter.)

APPENDIX 1

SUPPLEMENTAL SUMMARY AND DISCUSSION OF MERCURY EMISSIONS TESTING RESULTS TEST DATE DECEMBER 12, 2019

Executive Director
Thomas W. Sigmund, P.E.
Commissioners
Kathryn Hasselblad, President
James Blumreich, Secretary
Thomas P. Meitz, Vice President
Mark D. Tumpach, Vice President
Lee D. Hoffmann, Vice President

NEW Water
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January 23, 2020

Ms. Tania Taff
Air Management Engineer – Division of Environmental Management
Wisconsin Department of Natural Resources
2984 Shawano Ave
Green Bay, WI 54313-6727

RE: Testing for emissions of mercury from I08 without use of granulated activated carbon

Dear Ms. Taff:

The purpose of this letter is to submit and discuss results for emissions testing that Green Bay Metropolitan Sewerage District (GBMSD) has opted to conduct on Process I08, the fluid bed incinerator.

Background

In 2018, GBMSD began operation of a new fluid bed incinerator (FBI) that is subject to 40 CFR 60, Subpart LLLL, Standards of Performance for New Sewage Sludge Incineration Units, which include limits for mercury emissions. GBMSD installed a granulated activated carbon (GAC) unit to control mercury emissions, if needed, to meet the new limits. Compliance emissions testing in October 2018 and May 2019 demonstrated that mercury emissions have been within the limits while operating the GAC.

A malfunction that occurred on November 7, 2019, described in a written report to the United States Environmental Protection Agency (US EPA) dated December 31, 2019, left the GAC inoperable. GBMSD implemented numerous alternative options for managing sludge, but after several weeks, determined that the ability to treat wastewater effectively would be compromised without incinerating some sewage sludge. As such, limited incineration of sewage sludge without the GAC began on November 21, 2019.

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To measure the mercury emission rate and evaluate the potential impacts of operating without the GAC, GBMSD conduct an emission test on December 12, 2019. All other emission control systems, (the combustion chamber temperature, a wet electrostatic precipitator, and scrubber) operate in accordance with their respective allowable operating parameters whenever the FBI is operated, including during the emission test. The enclosed report contains the results from that testing, which was conducted by Advanced Industrial Resources, Inc. Results show that the allowable mercury concentration exceeded the Subpart LLLL limit for new fluid bed incinerators while incinerating sewage sludge without operating the GAC.

While operating the FBI without the GAC might exceed the allowable mercury concentration, it does not pose a significant risk to the public. An air dispersion modeling evaluation was conducted by using the measured mercury emission rate without the GAC and comparing the results with health-based standards. The evaluation demonstrates that the impacts from the emission rate are well within state health-based standards. This evaluation is discussed in detail below.

Discussion

GBMSD conducted an emission test on December 12, 2019 to determine the mercury emission rate from the FBI without the GAC operating. The sludge feed rate during the test averaged 1.81 dry tons per hour, which is 85% of the 51 dry tons per 24-hour day capacity.

The measured mercury emission concentration from the December 12, 2019 test was 0.0220 milligrams per cubic meter (mg/m^3) corrected to 7% oxygen. While this emission concentration exceeds the Subpart LLLL emission limit, it meets several other standards, including the Subpart LLLL limit for new multiple hearth sewage sludge incinerators, as well as existing fluid bed and multiple hearth sewage sludge incinerators (see 40 CFR 60 Subpart MMMM). The measured mercury emission rate was 0.000646 pounds per hour (lb/hr), which meets the National Emission Standard for Mercury (see 40 CFR 61 Subpart E). This emission rate also meets Wisconsin's air toxics emissions standards for mercury (see Wis. Admin. Code§ NR 445, Table A). Table 1 compares the measured concentration and emission rate without the GAC in operation with each of these federal and state standards.

Table 1 Comparison of Mercury Emission Rate without GAC with Federal and State Standards

Regulation	Numeric Standard	Equivalent Hourly Standard	GBMSD FBI without GAC[1]	Meets Standard, Percent
Federal Standards				
Subpart LLLL New Fluid Bed Incinerator	0.0010 mg/m^3 @ 7% O_2		0.0220 mg/m^3 @ 7% O_2	Exceeds Standard
Subpart LLLL New Multiple Hearth Incinerator	0.15 mg/m^3 @ 7% O_2		0.0220 mg/m^3 @ 7% O_2	15 %
Subpart MMMM Existing Fluid Bed Incinerator	0.037 mg/m^3 @ 7% O_2		0.0220 mg/m^3 @ 7% O_2	59 %
Subpart MMMM Existing Multiple Hearth Incinerator	0.28 mg/m^3 @ 7% O_2		0.0220 mg/m^3 @ 7% O_2	8 %
40 CFR 61 Subpart E Sludge Incineration Plants	7.1 lb/24-hr	0.30 lb/hr	0.000646 lb/hr	0.2 %
Wisconsin State Standards				
NR 446.20(2) Sludge Incineration Plants	7.1 lb/24-hr	0.30 lb/hr	0.000646 lb/hr	0.2 %
NR 445 Table A Mercury, Inorganic Stack Ht > 75 ft	1,838 lb/yr	0.21 lb/hr	0.000646 lb/hr	0.3 %
NR 445 Table A Mercury, Inorganic Stack Ht > 75 ft	0.0405 lb/hr		0.000646 lb/hr	2 %

To estimate potential impacts on human health from operating the FBI without the GAC, GBMSD contracted with Short Elliot Hendrickson Inc. to conduct air dispersion modeling to calculate potential off-site mercury concentrations and to compare those potential impacts with state health-based standards. The ambient air quality standards for mercury are shown in the Wisconsin Administrative Code, NR 445, Table A.

These standards are a 24-hour average[2] concentration of 0.6 micrograms per cubic meter (µg/m^3) and an annual[3] average concentration of 0.3 µg/m^3. The air dispersion modeling was conducted in accordance with Wisconsin Air Dispersion Modeling Guidelines and the federal Guideline on Air Quality Models (40 CFR 51 Appendix W). A memorandum documenting the air dispersion modeling completed is enclosed.

For evaluation of the 24-hour standard, the actual days the FBI has run without the GAC and is anticipated to run without the GAC (November 21, 2019 through January 31, 2020) were modeled using the 0.000646 lb/hr mercury emission rate. The resulting highest impact, 0.00187 µg/m^3 is about 0.3 % of the 24-hour standard.

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[1] The emission rate and emission concentration shown on this table are based on emission testing conducted at the GBMSD facility on December 12, 2019 without the operation of the GAC.
[2] Wisconsin's 24-hour standard is 2.4% of the mercury TLV the American Conference of Governmental Industrial Hygienists.
[3] Reference Concentration for Inhalation Exposure for mercury from EPA Integrated Risk Information System.

For the annual standard analysis, the FBI was modeled as "off" for the shutdown period (October 19, 2019 through November 20, 2019), "on" at 0.000646 lb/hr during the actual days when the FBI operated or is anticipated to operate without the GAC (intermittently from November 21, 2019 through January 31, 2020), and then "on" at the permitted mercury concentration rate for the remainder of the 365 day period (February 1 through October 18, 2020). The resulting impact, 0.00004 µg/m³ is about 0.01% of the annual standard.

Table 2 – Modeling Results Compared with Ambient Air Standards for Mercury

Averaging Period	Modeled Concentration (µg/m³)	Ambient Standard (µg/m³)	*% of Standard*
24-hr	0.00187	*0.6*	*0.3%*
Annual	0.00004	*0.3*	*0.01%*

While operating the FBI without the GAC might exceed the allowable mercury concentration, modeling indicates that it does not pose a significant risk to the public. The air dispersion modeling evaluation demonstrates that the impacts from the emission rate are well within state health-based standards.

Please feel free to contact Julie Maas by phone at (920) 438-1045 or email at jmaas@newwater.us with any questions or comments you may have.

Sincerely,

GREEN BAY METROPOLITAN SEWERAGE DISTRICT

Thomas W. Sigmund

Thomas W. Sigmund, P.E.
Executive Director

c. Louise Gross, US EPA
Daniel Schaufelberger, US EPA
James Bonar-Bridges, WDNR
Thomas Henning, SEH

Enclosures:
1: Advanced Industrial Resources Sewage Sludge Incineration Unit Emission Test Report – Test Date December 12, 2019
2: SEH Technical Memorandum – Analysis of impact of Mercury Emissions from FBI

SEH

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TECHNICAL MEMORANDUM

TO: FILE

FROM: Jeremy Luebke

DATE: January 23, 2020

RE: Analysis of Impact of Mercury Emissions from FBI
SEH No. 153650 GODFR

The Green Bay Metropolitan Sewerage District (GBMSD) operates a fluid bed incinerator (FBI) and associated air pollution control equipment at their wastewater treatment plant located in Green Bay, Wisconsin. The purpose of this memorandum is to evaluate the potential impacts of operating the FBI without one of the emission control system, the Granular Activated Carbon (GAC) system. The GAC is designed to control mercury emissions.

The purpose of this memorandum is to document that the GBMSD demonstrates compliance with Wisconsin Administrative Code Chapter NR 445 Table A - *Emission Thresholds, Standards and Control Requirements for All Sources of Hazardous Air Contaminates,* specifically for mercury compounds, from the FBI (I08) when the GAC control device is offline.

NR 445.07 Emission thresholds, standards, control requirements and exemptions, paragraph (1)(a) states the following:

> *No owner or operator of a source may cause, allow or permit emissions of a hazardous air contaminant listed in Table A in such quantity or concentration or for such duration as to cause an ambient air concentration of the contaminant off the source property that exceeds the concentration in column (g) of Table A for the contaminant.*

Column (g) of Table A lists the Ambient Air Standard (per time period in column h expresses as micrograms per cubic meter).

NR 445.08 describes the acceptable methods by which to demonstrate compliance with the Ambient Air Standards in Table A. NR 445.08(1) requires that the determination of compliance shall be done while the source is operating under normal permit conditions, or in the absent of a permit, the maximum theoretical emissions. The incinerator mercury emission rate was determined in a December 12, 2019 stack test. The incinerator was operating under permit compliant conditions without the GAC operating, resulting in a worst-case scenario emission rate for mercury emissions. The emission rate for mercury, averaged over all three runs is 0.000646 lb/hr.

Compliance Demonstration via NR 445.08(2)(a) – Thresholds for Emission Rates

The first method that can be used to demonstrate compliance, as provided in NR 445.08(2), paragraph (a) is to show that emissions from the incinerator are below Table A Thresholds for Emission Points (expressed as pounds per hour or pounds per year) in columns (c), (d), (e), or (f), depending on stack height. The incinerator stack height has a height of 120 feet above grade, requiring emissions to be

compared to column (f) "Emissions from Stacks ≥75 ft" threshold values. If the source has emission rates less than the thresholds in Table A, column (f), it is assumed that the Ambient Air Standards in column (g) will not be exceeded.

NR 445.07 Table A, column (f) threshold values are not exceeded for inorganic mercury. In the following **Table 1 – Mercury Emission Rate Comparisons to Table A Thresholds for Emission Points**, Table A threshold values are compared to the stack test incinerator emission rate.

Table 1 – Mercury Emission Comparison

	December 2019 Stack Test (lb/hr)	December 2019 Stack Test (lb/yr)	Table A Thresholds for Stacks ≥75 ft (lb/hr)	*% of Table A Thresholds*
Hg	0.000646	-	0.0405	*1.60%*
	-	5.66	1,838	*0.31%*

Note: The annual emission rate is the hourly rate, 0.000646 lb/hr, multiplied by 8,760 hour per year.

Compliance Demonstration via NR 445.08(2)(b) – Ambient Air Concentrations

Secondly, NR 445.08(2) paragraph (b) provides the option to demonstrate that the ambient air concentration off the source property is less than the column (g) "Ambient Air Standards" for mercury are surpassed. This demonstration is conducted through dispersion modeling as shown below.

This dispersion modeling analysis was performed using the AMS/EPA Regulatory Model (AERMOD) (Version 18081) with the Lakes® AERMOD user interface. Five years (2011-2015) of preprocessed meteorological data, obtained from the WDNR website, were used in this analysis. The surface meteorological and upper air meteorological data were taken from the Green Bay, WI station.

The receptors used in this analysis consisted of a grid with fenceline receptors placed every 50 meters, 50-meter receptor resolution out to a distance of one kilometer, and receptors placed every 200 meters until a distance of two kilometers. Receptor points within the facility were not considered. As per WDNR policy, terrain elevations as derived from AERMAP were incorporated in the modeling analysis. Elevations were determined using USGS National Elevation Dataset (NED) files obtained from the USGS National Map Seamless Server website. USGS NED data is in conformance with the North American Datum of 1983 (NAD 83).

Previous WDNR modeling parameters for the incinerator (I08) were used for stack location, height, and diameter. However, for this modeling exercise, actual measured parameters from the December 2019 stack test were used for exhaust temperature, exit velocity, airflow and emission rate. Parameters can be found below in **Table 2**.

Table 2 – Modeling Input Parameters

Stack ID	Description	X	Y	Base Elevation	Height	Diameter	Rainhat	Exhaust Temp	Exit Velocity	Air Flow	Mercury
		meters	meters	meters	feet	feet	Y/N	F	m/s	acfm	lb/hr
I08	Fluid Bed Incinerator	420555	4931795.4	179.0	120	2.0	N	113.3	15.63	9,267	0.000646

Ambient air standards are not surpassed in this dispersion modeling demonstration. Modeling results are shown below in **Table 3**.

Table 3 – Modeling Results Compared to Table A Ambient Air Standards

	Averaging Period	Statistic / Metric	Modeled Concentration ($\mu g/m^3$)	NR 445 Ambient Air Standards ($\mu g/m^3$)	*% of NR 445*
Hg	24-hr	1st Highest	0.00187	*0.6*	*0.3%*
	Annual	1st Highest	0.00004	*0.3*	*0.01%*

Conclusions

The District can demonstrate compliance with NR 445.07(1) requirements. Uncontrolled mercury emissions from the incinerator do not surpass Table A, column (f) Thresholds for Emission Points or column (g) Ambient Air Standards.

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